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The Outlook

Two Voices

INTRODUCING the Air Estimates on March 4th, Sir Archibald Sinclair, Secretary of State for Air, said that we intended to resume the bomber offensive against Germany on the largest possible scale at the earliest possible moment. A few days before, on February 25th, Sir Stafford Cripps, Leader of the House of Commons, had said that the policy of building up a bomber force had been initiated at a time when we were fighting alone against Germany and Italy, and it then seemed the most effective way in which we, acting alone, could take an initiative against the enemy. Since the success of the Russian armies and the entry of the United States into the war, the original policy had come under review, and was indeed kept constantly under review. The Government, said Sir Stafford, were fully aware of the other uses to which our resources could be put, and the moment they arrived at a decision that the circumstances warranted a change, a change of policy would be made.

These two statements by two Ministers suggest that the Government is not at all clear in its mind as to what our policy ought to be. Sir Archibald Sinclair certainly disregarded the words of Sir Stafford Cripps, and at first sight it seems as if the two Ministers were contradicting each other. Sir Stafford, it may be noted, had only just joined the Government at the time of his speech, and he must have been speaking from his brief, not from his own personal knowledge of the deliberations of the Government. Sir Archibald, on the other hand, is not a member of the War Cabinet, and in presenting the Air Estimates, was merely the spokesman of his department. Looked at in that way, there is no necessary contradiction between the two speeches. The Air Minister once again affirms the intention to hammer the German war effort with all the strength of the bomber force at his command. The Leader of the House hinted that the effort now devoted to multiplying that bomber force may be curtailed, presumably on the production side. All the same, it is unfortunate when the speeches of two Ministers give the impression that there is a lack of unanimity in the British High Command.

An Uneasy House

THE debate which followed the speech of the Air Minister gave ample evidence that the House of Commons is uneasy about the higher direction of the Royal Air Force. There is no uneasiness at all about the behaviour and skill of the pilots and air crews, or about the excellence of the designs produced by the aircraft firms. All speakers combined to praise our airmen, and quite rightly. The criticism was all directed against the higher organisation of the Air Force. Speaker after speaker dealt with the relations of the Air Force and the Army. Nearly all agreed that the Air Force and the Navy are now working together in full accord—a happy change from the conditions of a few years ago—and the still-vexed question of whether the Coastal Command ought to be under the Admiralty was ignored by nearly all Hon. Members.

Many nostrums were advocated for securing better air support for our expeditionary forces in the future. Some Hon. Members were in favour of giving the Army its own air arm. Others did not want that, but urged strongly that Army commanders should have absolute

operational control of the air contingents working with their troops.. One speaker opposed the transference of squadrons from the Air Force to the Army, but urged that the latter should build up its own air arm, as it had a number of trained pilots among its officers. Several asked for information about what Air Marshal Barratt and his Army Co-operation Command are doing. A contributor to a recent issue of *Flight* also raised that point; and, indeed, the complete veil of secrecy which shrouds that Command makes thoughtful and constructive suggestion very difficult.

At any rate, the House of Commons showed clearly that it is not happy about the relations of the Army and the Air Force, and its uneasiness is comprehensible. Sir Archibald Sinclair's line of objection, that the pilots and crews resent reading about proposals for alterations (reforms, some would call them) and that such proposals do harm is not convincing. As one Hon. Member pointed out, our war policy cannot be dictated by the feelings and prejudices of junior officers. If a reform is for the good of the national war effort, it should be carried through. Junior officers will, of course, loyally obey orders whether they personally approve of the policy or not.

Record Production

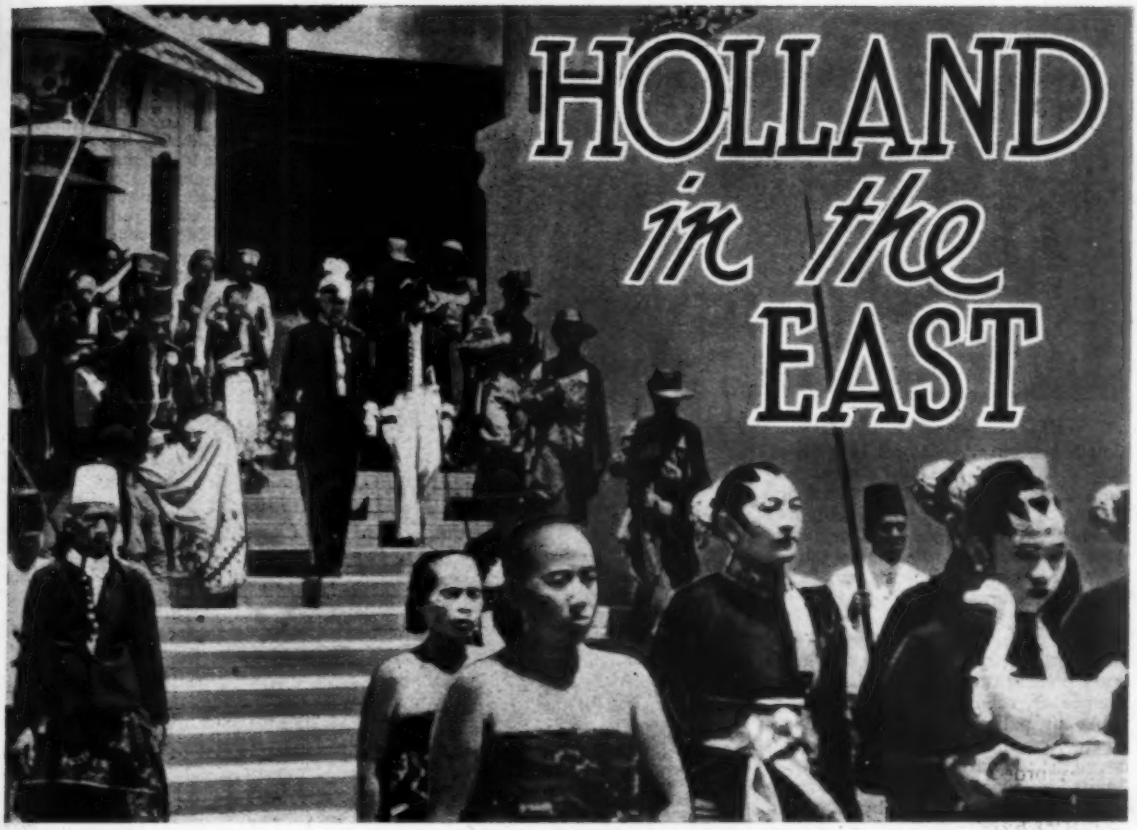
THE new Minister for Aircraft Production has lost no time in getting into personal touch with the industry which he now controls. Last Friday he visited a number of factories in the north, and he was able to announce to workers there that the previous week's output of aircraft engines had been the largest ever recorded.

During the early stages of the war there were occasions when the output of engines failed to keep pace with that of airframes. That was but to be expected, for the preparation of tools and jigs for the manufacture in huge quantities of aircraft engines must of necessity be a much more complicated business than the corresponding jigging and tooling for an air frame. That the industry has been able to make such wonderful strides is a matter for congratulation, especially when one bears in mind the heavy demands on machine tool manufacturers and the makers of raw materials.

Gratifying as this record engine output is, what is even more remarkable is that the high production rate has not resulted in any lowering of quality. That no such lowering of standards is being permitted is, perhaps, the highest praise that could be given to those responsible for our engine production. The fear expressed when large numbers of women workers were introduced in factories does not appear to have been well founded. Results seem to show that their work is in every way as good as that of the men whom they replaced.

Of airframe production Col. Llewellin said that it was "satisfactory." If the Minister for Aircraft Production was not able to claim a record week, the fact need cause no disappointment. With a much greater proportion of our productive effort devoted to four-engined bombers, the output, as counted by numbers, must suffer. Many more man-hours are required for these large types of aircraft, but their range and bomb load are correspondingly greater, a fact which does not emerge from lists based upon numerical units.

SHORTENING THE ODDS: If our recently proclaimed parity in aircraft is in numerical terms, then our punishing power must be much greater than that of the Axis. Not even the four-engined Focke-Wulf Condor can carry a load of bombs comparable with that of the Short Stirling. The four Stirlings in this photograph have a combined bomb load of 32 tons.



HOLLAND in the EAST

Respect for native customs underlies Dutch colonisation. Here is the Sultan of Java with his train on a ceremonial occasion.

Fair Play in Colonisation : Native Airmen Train With Netherlanders : Some Aircraft Types Used : Growth of Military and Civil Flying

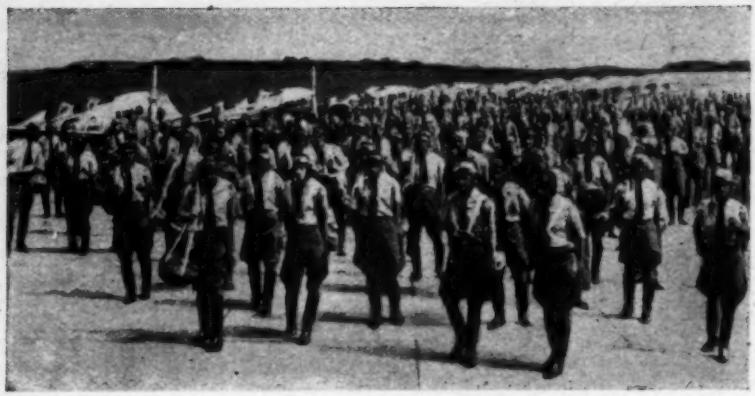
EVEN those of us who have never had the chance to visit the Netherlands East Indies have been saddened and angered by the Japanese violation of those lovely islands. As colonists the Dutch are second to none in their fair-minded administration, and the peoples of Sumatra, Java, Bali and the other islands have been happy and increasingly prosperous under it.

Overrun by the soulless militarism of the Japanese with its attendant destruction of life and property, the threat of subjugation by such a cold-hearted race with its Nazi-inspired doctrine of cruelty and suppression is a tragic prospect for Dutch and natives alike. Under the tolerant, kindly and helpful guidance of the Netherlanders, the people of the islands, with their many differing ideas and ideals, have been welded together into a national unity, their varying religions and cultures respected and their political notions given freedom of expression under a complex system of self-government by the People's Council set up in 1918. This democratic parliament, made up of 30 members representing the native Indonese classes, 25 standing for Netherlanders and five for Chinese or Arabs, made the laws for the entire Netherlands East Indies.

The way of the Axis with such organisations needs no stressing.

The success of the Dutch colonisation of these islands, in fact, is rooted in the fact that the native peoples have not been treated by them as inferior slave races. Educa-

Ground staff of the Netherlands East Indies air corps at work on Wright engines such as are fitted to their Dornier Do-24 flying boats, bought from Germany before the war.



HOLLAND

(Left) Dutchmen, Indonesians and Chinese fly together at the training stations where, during the expansion of their defence forces, many hundreds of young men qualified as pilots and aircrew personnel. This picture shows potential pilots with Ryan trainers in the background.

(Below) The crew of a Martin 139 bomber preparing to embark, no doubt for an attack on invading forces. The Dutch East Indies acquired their first Martin aircraft in 1915 and this make continued to be one of their favourites from then onwards.

tion has been given to all in spite of the difficulty of many languages, and, although native children are encouraged to learn Dutch, if only for business purposes later in life, their own native tongue remains an important subject even in the higher grades. Nor is there any segregation of natives from Dutch, for a very considerable number of Indonese and Chinese students attend the "European" schools after passing through their own native elementary schools.

As in politics, education and industry, so in their military and naval services; the native peoples have been invited and encouraged to take a share and play their part side by side with their Dutch comrades.

As long ago as 1914 the significance of air power was appreciated, and the very fact that their island Empire included hundreds of miles of sea lanes gave it even greater point. The value of aircraft in the defence system of the East Indies was obvious, and the principle they adopted was similar to that of America, whose aircraft they have always extensively employed, namely, the formation of an army air corps and a navy air arm.

One of the first foreign contracts ever negotiated by the well-known American firm of Glenn L. Martin, Baltimore, was with the Netherlands East Indies in 1915, and Martin aircraft have been prominent in their air corps from then onwards. Latterly, of course, other American aircraft have also seen service among the "Spice Islands," including Lockheeds, Curtisses, Brewsters and Ryans, the last-named being the elementary trainer employed both in landplane and floatplane versions.

Conscription Introduced

After the invasion of their mother country the Dutch Far Eastern empire set about strengthening its defences, first of all introducing conscription for all able-bodied Dutchmen between the ages of 18 and 46, and subsequently the People's Council extended compulsory service to the native population also, appropriating the sum of $10,000,000 to put the necessary arrangements into effect. Here, again, the fair-play method of the Netherlanders showed itself, as always, for the government emphatically assured the country that native militants would be treated exactly the same as Europeans. In the air services, Indonese and Chinese have, since the Japanese onslaught brought thousands of them flocking to the defence of their beloved islands, trained, flown and worked on equal terms and side by side with European pilots, aircrews and ground staff.

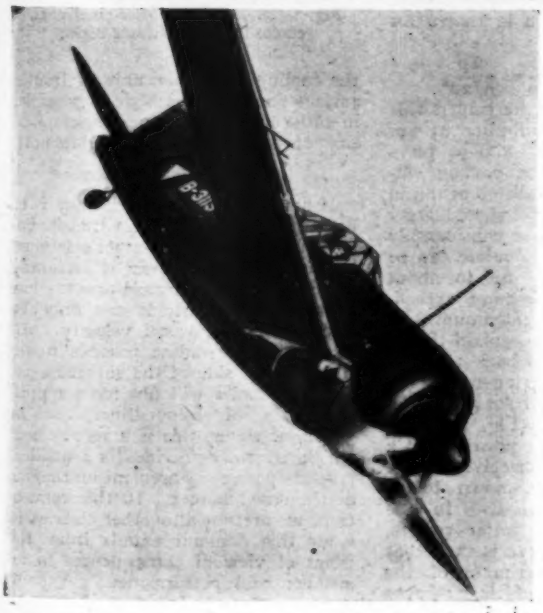
Their fleet air arm always was, of course, a particularly

Inertia starters are fitted to the floatplane version of the Ryan ST-A trainer (125 h.p. 4-cyl. Menasco), on which ab initio training is given to N.E.I. Fleet Air Arm pilots. The latest seaplane edition, the ST-3S, has a 160 h.p. Kinner radial engine.

AND HE EAST

(Right) From the day Germany invaded their Mother Country, the Netherlands Far Eastern fleet, with its air arm, intensified the patrolling of the thousands of square miles of tropical seas surrounding the islands. In the picture a Fokker C.11-W reconnaissance seaplane is being catapulted from a Dutch cruiser.

(Below) Anti-Aircraft batteries of the N.E.I. army have inflicted substantial losses on raiding Japanese bombers. Here we see a 40 mm. Borfors gun team in action. The headgear worn appears to be a sort of "tin topee."



Among the several types of American aircraft used by the N.E.I. air force is the Brewster Buffalo, which has put paid to the account of many a Nippon raider in spite of invariably being greatly outnumbered in air combat.

vital section of the N.E.I. air force and, just before the Far East conflict began, its aircraft were usefully augmented by the addition of a number of Catalina flying boats. The first two of these arrived in the Indies in the middle of September last, commanded by officers of the N.E.I. Navy Air Arm, who flew the machines from the Consolidated factory at San Diego, California, and they met with an extremely cordial welcome on reaching their home base.

Before the acquisition of the Catalinas (many more followed those first two, of course) the biggest flying boat in the service of the N.E.I. Navy Air Arm was the German-designed Dornier Do-24. These differed from the Do-24s of the *Luftwaffe*, however, in that they were fitted with Wright Cyclone engines instead of the German B.M.W. radials, and, in spite of being three-engined aircraft as against the Catalina's two-engined design, they were very much slower and possessed little more than half the range of the latest American flying boats.

Another machine used in fair numbers by the "flying Dutchmen" of the Indies was designed by one of their own countrymen, the late Anthony Fokker. This is the Fokker C.11-W, an open two-seater reconnaissance seaplane, shown in an accompanying picture being catapulted from a Dutch cruiser. This aircraft was obtainable with a choice of engines and it is probable that the Wright Cyclone was fitted.

Civil Flying

No reference to Dutch aviation in the East would be complete without inclusion of their rapid peacetime development of civil air transportation among the 3,000 islands which made up the archipelago.

In actual fact, however, air transport within the islands had its beginnings outside the islands, and it sprang from the need to establish quick communication between the Indies and the mother country. By 1935 Royal Dutch Airlines (K.L.M.) had developed a bi-weekly service from Amsterdam to Batavia on a 5½-day schedule. Then the Royal Netherlands Indies Air Company (K.N.I.L.M.) came into being and, beginning with a daily service between Batavia and other towns on Java, steadily spread a network of services over the whole of the Indies, with extensions to Indo-China and Australia, until, in 1941, they flew nearly 2,000,000 miles over 6,000 miles of routes.

Plans were practically complete for a link-up with Pan American Airways at Manila when the first Japanese bombs rained down on Pearl Harbour.

INTER-COOLER DESIGN

Air-cooling the Supercharge : Speed and Altitude of Flight the Deciding Factors : Power Required to Overcome Drag, Extra Weight, and Pressure Loss

By W. FRIEDERICHS

WHEN a supercharger is driven at high speed, heating of the air takes place, and presently a point is reached when it becomes necessary to cool the air before it enters the engine. This article, taken from the "Jahrbuch der deutschen Luftfahrtforschung," 1938, and translated by Mr. K. M. M. Goggin, of Department R.T.P. of the Directorate of Scientific Research, deals with some of the problems encountered when air has to be cooled by air.

THE air-permeability of an air-cooler for a supercharger is discussed in comparison with a water cooler: different types of coolers are described with reference to their advantages and disadvantages. With regard to the total power requirement of the cooler—power required to overcome drag, power required to tow the weight, and power required to compensate the pressure loss on the side of the supercharger air—the deciding factors are the velocity and altitude of flight; these are also the important factors for deciding whether intermediate or final cooling is to be preferred. The end cooler has certain advantages over the intermediate cooler on account of its lower weight and smaller frontal surface, but the power required to drive the supercharger is greater, because the compression is almost entirely adiabatic. Therefore, at not too high velocities of flight, there is a minimum in the total power requirement for the intermediate cooler, due to the power economy arising from polytropic compression.

In conclusion, problems concerning materials are discussed and the cooler made by the firm Süddeutschen Kühlerfabrik, Julius F. Behr of Stuttgart-Feuerbach, is described.

In contrast to the conditions met with in water coolers when on one side, it is still possible to reckon with very good heat transfer numbers, in this case there is only the bad α-value for air on the side of the cooling medium. For this reason, the cooling surfaces have to be relatively large in proportion to the quantity of heat carried away; for a 1,000 h.p. engine of normal charging and a 6,000 m. altitude, the order of magnitude is about 20 m² for the final cooling and 60 m² for intermediate cooling. This assumes that a portion of the work is done by indirect surfaces. For direct surfaces these values will lie somewhat lower. The heat transfer numbers on the side of the cooling air are determined by the velocity of flight, the physical constants of air at the appropriate altitude and the permeability of the cooler.

Permeability

The permeability, η_{ai}, is determined by the resistance value c_w, corresponding to the value which is known for water coolers,

$$\frac{\text{pressure loss}}{\text{dynamic pressure}} = \frac{\Delta p}{\rho/2v^2}$$

While in the case of water coolers this value is limited to 5-6, because above this limit the cooling efficiency falls off again, in the case of supercharger air coolers considerably higher c_w-values can be reached, up to about 15-25, without exceeding the maximum. In order to explain this, I must go back to a representation which has already been given previously (Fig. 1). The cooling power of a cooler receiving free flow is known to be $Q = \eta_{ai} \cdot \eta_{th} \cdot C$. In the case of water coolers, this curve is such that the maximum of the cooling-efficiency curve lies at $\eta_{ai} = 0.35$, or c_w is about 7 and 8. At this permeability the η_{th} value for the air cooler is only about half as great as the η_{th} value for the water cooler; this is obvious from the consideration that the heat transfer number contains a value of the order of magnitude of the heat transfer number on the air side, instead of the large α-value for water. The maximum of the cooling power for the air cooler is therefore displaced, corresponding to the smaller permeabilities, and therefore the higher c_w-values. These considerations therefore permit great depths at high c_w-values in the case of coolers receiving free flow. It should also be mentioned that the cooling power per unit of frontal surface should be as high as possible, in order to use up the minimum quantity of power from the engine unit.

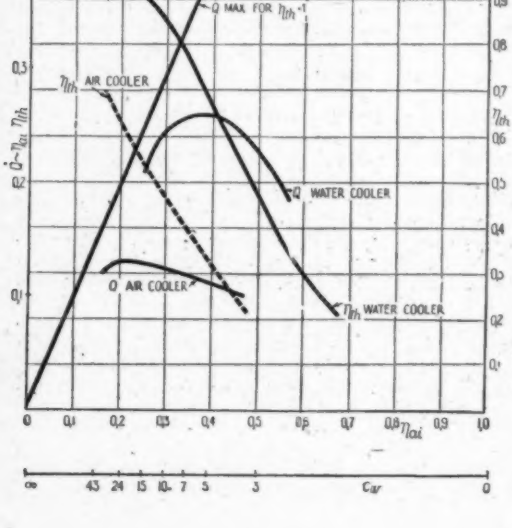

Q MAX. FOR η_{th}=1
η_{th} AIR COOLER
Q WATER COOLER
Q AIR COOLER
η_{th} WATER COOLER
$Q = \eta_{ai} \cdot \eta_{th}$
η_{th}
η_{ai}
0 0,1 0,2 0,3 0,4 0,5 0,6 0,7 0,8 0,9 1,0
∞ 43 24 15 10 7 5 3 c_w 0

Fig. 1. Efficiency of water coolers and air coolers in relation to drag coefficient c_w.

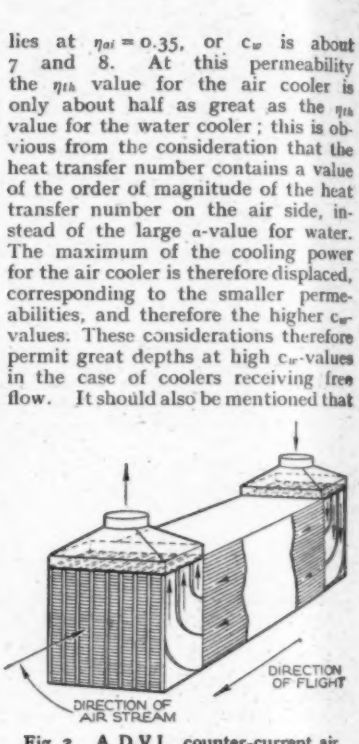


Fig. 2. A D.V.L. counter-current air cooler for high-altitude flight.

Cooling Efficiency

If maximum cooling efficiency is to be obtained, then the heat transfer coefficient on the supercharger side must be a maximum, which is naturally associated with increased pressure loss in the cooler—since it can only be achieved by increased velocity. Although it is nowadays possible to ensure, on the side of the supercharger, that the cooler will not have a pressure loss of more than 200 or 300 mm. water, this is a requirement which naturally provides for a smallest possible power requirement on the side of the supercharger. In this connection, we are not altogether clear as to what this demand entails from the point of view of consequences to resistance and performance. A point must therefore be found at which addition of the power required to tow the cooler to the increased power of the supercharger caused by the pressure loss gives a minimum value.

Before showing how these values lie approximately, I must first of all go into the details of cooler construction and thereby show how a predetermined pressure loss will affect the dimensions of the cooler.

Cooler Construction

In order to provide for the aforementioned heat exchange surfaces, it will hardly be possible to do otherwise than to combine these into a block cooler system; surface coolers will probably have to be abandoned, since either it may be impossible to arrange them, or else they may become too complicated.

Only counter-current or transverse-current will come into consideration for the relative directions of flow of the two media. On account of the large temperature changes which occur, it will be supposed in the first place that cooling by counter-current flow will have important advantages over transverse-current flow, as is usually the case with water cooling.

The D.V.L. therefore designed a counter-current cooler for supercharger air, which is shown in Fig. 2. In principle it is a plate cooler in which the cooling air flows past the supercharger air in counter-current, separated by plates. In order to increase the cooling surface, both sides,

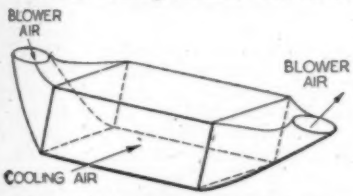


Fig. 3. A simple type of cross-current air cooler.

both on the side of the cooling air and also on the side of the supercharger air, are provided with ribs. The distances between the separating walls and the ribs can be constructed, according to requirements, so that optimum cooling efficiency is obtained with minimum expenditure, i.e., in any case special care is taken that the air velocities to be expected still lie in the turbulent region, in order to be able to utilise the favourable heat transfer numbers occurring in that region.

The second principle was the normal transverse-flow cooling system, in which the cooling air flows in cross-current past the supercharger air, Fig. 3. In this case it is possible, for example, to use a normal ribbed tube system similar to water coolers; the latter type is provided with a different ratio of direct to indirect surface, in accordance with the thermodynamic requirements. This has already been done in various ways with good success.

By comparison of the two types of coolers it can be established that the counter-current cooler, as proposed by the D.V.L., can be easily fitted, since the two attachments for the inlet—and outlet—of the supercharger-air can lie inside the fuselage and give no additional drag. On the other hand, in the case of the transverse-current cooler, conditions are somewhat more unfavourable, because the lateral chambers must necessarily increase the air drag. In this case, the cooler would have to be built in the wing, for example, in such a way that the chambers receive a natural cowling. However, if the transverse-current cooler is also constructed as in Fig. 4, this disadvantage is already partly removed.

Pressure Loss

In order to obtain the specified amount of pressure loss on the side of the supercharger air, it is naturally possible to increase the frontal surfaces and so to select the dimensions of the channels, that a suitable value for the pressure loss is not exceeded. In any case, this naturally amounts to the same thing as an increased power required for towing. There is a slight advantage in the case of transverse-current coolers of the above type. In this case—although only within certain limits—the pressure loss can still be reduced, apart from increasing the frontal surface, also by increasing the depth, because in this way a greater cross-section is available to the air. From considerations of this kind it is, nevertheless, still difficult to give the preference to one or the other system, because with these coolers too many points of view have to be considered in special cases, whereby the one or the other type of construction can give favourable values.

For individual coolers it is of decisive importance to note the following points:—Cooling efficiency, weight, pressure loss, ease of fitting, shape of the frontal surface, depth, compression strength, ease of repair and costs of production.

Power Requirement

Since reference will frequently be made in the following to the power requirement of a supercharger cooler, we will briefly enumerate the individual values from which this power requirement is made up.

1. Resistance L_w (of the cells) caused by the size of the frontal surface.
2. Towing power (L_g) corresponding to the weight of the cooler.
3. The power required on account of the greater wing surface, L_f, caused by 2; this is neglected in the following.
4. Increased power required for the supercharger on account of the pressure loss on the supercharger air side of the cooler (L_{Lk}).
5. Supercharger power for adiabatic compression (L_{ad}) taking into account an efficiency of 75 per cent.
6. Power for compression with intermediate cooling (L_{zk}).
7. Reduction of the power required to drive the supercharger by use of an intermediate cooler. $L_L = L_{ad} = L_{zk}$. Therefore the total power requirement for the cooler is now: $1+2+4=L_k$.

Since, as described above, the pressure loss on the side of the supercharger air, the frontal surface and weight are dependent on one another, on the other hand these are factors which contribute a certain amount to the power requirement L_k, and it will now naturally be necessary to consider the values of the dimensions of the cooler and the value of the pressure drop at which the minimum power requirement occurs, and which, naturally, has to be aimed at, unless

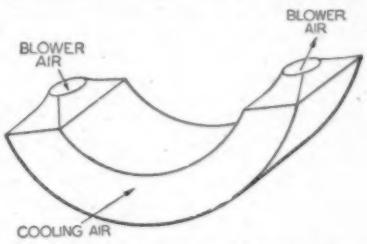


Fig. 4. This type of cross-current cooler can be mounted to offer low drag.

some other factor is decisive. Fig. 5 shows, by way of example, how the power requirement of a cooler, L_k, can vary. In the example, for a supercharger pressure loss of 250 mm. and a frontal surface of 6 dm², the power requirement (L_{Lk}) for the pressure loss was found to be about 6 h.p. For the small velocity of 70 m/sec., which was provided for in this case, the resistance power L_w amounted to 4 h.p. and the towing power corresponding to the weight, L_g, was 3.6 h.p. Thus, in this case, a smaller total power is still obtained with a somewhat larger frontal surface and therefore smaller pressure loss. For more rapid machines, however, the picture will change greatly and the power minimum (L_k) will lie at considerably higher pressure losses and smaller frontal surfaces.

For the question of whether intermediate or final cooling will be preferred, equally important questions of the power requirement have to be cleared up. Obviously, for intermediate cooling there are large coolers which, owing to large frontal surfaces and high weight, are more unsuitable than the end coolers from the point of view of towing power; the latter have correspondingly smaller frontal surface and frontal weight, on account of the greater difference in temperature from that of the cooling air. On the other hand the power requirement of a supercharger having an end cooler and adiabatic compression, is correspondingly greater than that for interme-

INTER-COOLER DESIGN

diate cooling, which approximates to isothermal compression with the lowest power requirement.

In order to explain these questions clearly, the power requirement of a supercharger, i.e., L_{ad} and L_{zk}, will be compared for the two cases by means of an example. For an engine of approximately 1,000 h.p. the supercharger air at about 6,000 m. altitude will be cooled by means of an external temperature of −24 deg. C. from 140 deg. C. to 90 deg. C. in a final cooler, the quantity of heat to be carried away being 40,000 kcal/hr. For the intermediate cooler, the corresponding temperatures will be 50 deg. and 0 deg. respectively. If the power requirement of the supercharger is calculated in each case, then for the intermediate cooler there is a power economy for the supercharger amounting to about 18 h.p., the efficiency of the supercharger being taken as 75 per cent. In this case an end cooler was taken as having a frontal surface of 6 dm² and a depth of 450 mm. at a weight of 27 kg. A rough calculation gives, for the low velocity of 70 m/sec. dealt with in this case, a power requirement of $L_k = 13$ h.p., whereby in the calculation the additional power requirement, L_f, due to the extra wing surface, the increased surface drag and the increased surface weight have not been taken into account. The intermediate cooler in the same case gives $L_k = 24.3$ h.p., for a frontal surface of 14 dm² and a weight of 70 kg.

The weights are total weights including the fixture, and therefore not the weights of the pure block systems. In calculating the power, a c_w-value of 0.3 was taken for the cooler; this value had been obtained previously from measurements carried out at Aachen with a cowled radiator installed below the engine. The propeller efficiency was taken to be 70 per cent. Therefore, for the end cooler, in this case there would be an economy of 10.7 h.p. in the power required to tow the cooler, L_k, by comparison with that for the intermediate cooler, but there is an increased expenditure of power to drive the supercharger, L_L, of 18 h.p. In this case,

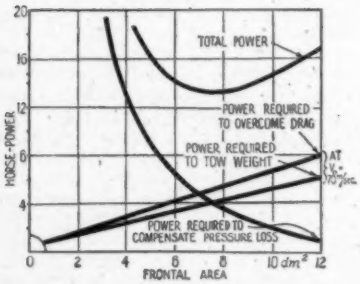


Fig. 5. Power requirements of supercharger coolers.

in spite of the larger frontal surface, the preference would be given to the intermediate cooler. However, at a higher velocity of flight the individual values can alter greatly with respect to one another.

The small velocities of flight which have been used here have arisen because the air coolers which have been previously designed by my firm were determined at this velocity. At higher velocities the end cooler will probably possess the smallest power requirement; however, in any case, a subsequent calculation is necessary since the supercharger power also arises. Although from the points of view of power the intermediate cooler should not prove necessary for high-velocity machines, it will certainly prove necessary for high altitudes above 12 km.

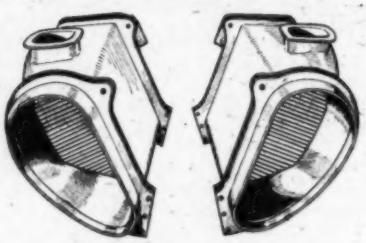


Fig. 6. This type of cooler was found to give high values of pressure loss.

Cooler for High Altitudes

With regard to coolers for high altitudes, details have already been given by Sabel at the conference on coolers at Stuttgart; according to him the frontal surfaces for high altitudes are still relatively small. Owing to the bad heat transfer conditions prevalent at great heights the cooler would have to be increased, but this is partly counterbalanced by the low temperature. Since it is required to have a constant outlet temperature from the cooler, the quantity of heat to be led away is increased, which results in an increase in the frontal surface of the cooler. The values given by Sabel for a 600 h.p. engine at 8,000 m. altitude were about 8 dm² for end coolers; at 12,000 m. altitude, 10 dm² for end coolers and 5 dm² for intermediate coolers.

Materials

The weight of modern supercharger-air coolers lies almost exactly at 1 kg. per dm³ of cooler-block. Since these copper coolers still have a relatively high weight, under certain circumstances a light-metal construction will represent an improvement from the point of view of economy in weight. Since the surfaces can hardly be joined by soldering for reason of corrosion, it will be necessary to weld the joints, but only if a strong material is used. It is then questionable as to whether a great advantage in weight will result, particularly since present-day coolers are already constructed with the smallest possible wall-thicknesses of 0.07 mm. The following table gives a comparison of the weights of a copper and a light-metal cooler:—

	Copper Cooler—kg. dm³ of Cooler Block	Light-Metal Cooler—kg. dm³ of Cooler Block
Weight of Block ...	0.6	0.5
Weight of Frame ...	0.2	0.2
Weight of Tin ...	0.2	—
	1.0	0.7

This is reckoning that the wall-thickness of the light-metal cooler is twice that of the copper cooler.

An Actual Cooler

I should now like to speak briefly about the supercharger cooler which has already been constructed by the Süddeutschen Kühlerfabrik J. F. Behr, Stuttgart-Feuerbach.

The coolers shown in Fig. 6 were constructed for a quantity of air of 1.2 kg/sec., to be cooled from 140 degrees to 90 degrees at an altitude of 6,000 m. Each cooler has a frontal surface of 2.6 dm². Since for certain reasons the test flights were first of all made at low altitudes, the cooling obtained was from 105 to 85 degrees at an external temperature of 25 degrees C. Since the frontal surfaces were kept very small, when used as cross-current coolers with a relatively unfavourable supply of blower air, they gave high values for the pressure loss, while from the point of view of cooling efficiency they were sufficient at the corresponding altitudes. In this case it would be possible, for example, to increase the frontal surface, at the expense of the resistance power, in order to reduce the pressure loss. The cooler shown in Fig. 7 was built as a substitute for this cooler and gives values for the pressure loss which lie within the permissible limits of the requirements laid down by the firm.

(*Continued at foot of next page.*)

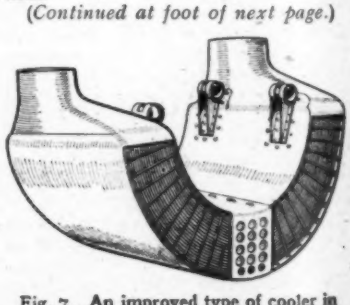


Fig. 7. An improved type of cooler in which pressure loss was kept within permissible limits.

STUDY OF THE STUKA

Dive Bombers Have Their Limitations : Successful British Alternative : The Air-borne Torpedo Also Vindicated

By E. R. CAMPBELL

FOR some time previous to the outbreak of this war the German Propaganda Department went to great lengths to create for their dive bombers a reputation which appeared to be borne out in the Polish campaign and in Belgium and France. This reputation persisted until the "dreaded Stukas" were utterly defeated in the autumn of 1940 by a comparatively tiny force of British fighters which, Goering asserted, were "far inferior in design and manufacture to contemporary German types." This defeat was a bitter blow to the Germans, who learned through experience that dive bombers were helpless against organised fighter opposition.

Certain elements of the Press in this country have for some time past been agitating for dive bombers to support our armies in the field. Instead of this, far more effective methods have been devised to provide such support with greater economy in crews and aircraft. In Libya, the Beaufighter and the Hurricane IIB bomber have been used to great effect. Instead of diving on their targets these machines fly almost at ground level to deliver their attacks and are in sight for so brief a period of time that troops have no time to bring their weapons to bear on them.

Hurricane Bomber

The Hurricane carries two 250-lb. bombs, and when it has released these it still has a colossal fire power and is once more a formidable fighter. The Beaufighter, with its heavy armament of six machine-guns and four 20-mm. cannon, is unequalled for strafing motor transport, armoured cars and light tanks, and there seems no reason why it should not be equipped with two heavier cannons in place of the 20-mm. guns and so become an extremely mobile and effective anti-tank weapon. It seems that these two types serve the purpose of Army co-operation in offence more than the conventional dive bomber.

The second duty of the dive bomber is the destruction of enemy shipping and, where merchant ships and lighter naval craft are concerned, it is the best weapon for this purpose, being far more accurate against a moving target than a bomber which releases its bombs from a great altitude while flying level. When, however, the target is a modern capital ship, the bomb has no decisive effect and losses in attacking aircraft are usually heavy.

Britain has been the pioneer of a weapon which, prior to the war, aroused more controversy than any other. It is, of course, the air-borne naval torpedo, which has entirely justified the faith which its supporters rested in its powers. The opponents of this weapon asserted that attacks of this nature were suicidal. However, events have proved that this is not so, and that the torpedo can be used to reduce the speed of enemy craft and enable them to be brought to action by our heavy naval units. Moreover, losses in such attacks have been astonishingly light. So successful has this weapon proved that our enemies have paid us the supreme compliment of imitating us. Recently the Savoia Marchetti 94 and the He 111E have appeared in service in the *Regia Aeronautica* and *Luftwaffe* respectively, both being torpedo-carrying aircraft.

Comparison

To sum up, the advantages of the dive bomber are, briefly, as follows:—

(i) They can be produced quickly and crews need not be especially skilled, although reckless courage is essential.

(ii) Its moral effect on opposing troops is greater than that of an artillery barrage, owing to the indescribably terrifying noise of the diving aircraft and the feeling that the aircraft is flying directly towards the observer.

(iii) High performance is not necessary, and so the aircraft need not be aerodynamically perfect—the Junkers 87B is a veritable "ugly duckling" of the air, little attention having been paid to streamline.

(iv) For attacking merchant shipping and naval craft up to about 8,000 tons it provides a cheap and exceedingly effective weapon.

On the other hand, we have several important considerations which rather outweigh all but the last-mentioned advantage:—

(i) Casualties, when used against seasoned troops, are heavy, as the machines present a fine target for small-arms fire as they pull out of their dives.

(ii) They are helpless against well-organised fighter opposition.

(iii) When operating against modern capital ships they are incapable of inflicting decisive damage and are very unlikely to affect seriously the speed of the vessel.

In view of these considerations, it is suggested that the Hurricane bomber, the Beaufighter and the torpedo bombers are far better for the purposes that have been mentioned than the dive bomber.

It is an indisputable fact that the Bismarck would have been able to escape had her speed not been so drastically reduced by torpedo attack from the air that our main forces were able to bring her to action. Again, the results of the historic attack on Taranto are indisputable proofs of the extraordinary capabilities of the air-borne naval torpedo, and it is exceedingly doubtful whether such results could have been obtained at such small cost, if at all, by dive bombing. In view of this, it would seem that, except for attacks on merchant shipping and on lighter naval units, the dive bomber is far from being as effective as the Germans would have us believe.

INTER-COOLER DESIGN *(Continued from p. 226)*

In addition, for testing for another engine, also for 6,000 m. altitude and for cooling from 140 degrees to 90 degrees C., various cross-current coolers were constructed; these possess frontal areas of 11 dm² for the end cooler and 21 dm² for the intermediate cooler. These coolers were purposely over-dimensioned somewhat, in order not to waste any time during the experiments by perhaps having to reconstruct a cooler which was too small. For the test, the coolers were able to be fitted as intermediate- or end-coolers, or they could be connected simultaneously as intermediate- and end-cooler. For the latter case, a measurement is available which gives the following temperatures, pointing to complete over-dimensioning:—

	Degrees.
External temperature	−20 C.
Entrance of supercharger air into the intermediate cooler	+53 C
Exit of supercharger air from the intermediate cooler	− 5 C
Entrance of supercharger air into the final cooler	+59 C
Exit of supercharger air from the final cooler	+10 C.

Since much has been said regarding the thrust of the cooler, which is said to even lead to negative resistances under certain circumstances, I would like to give quite briefly the reduction in resistance brought about by the effect of thrust; in the above-mentioned cases the resistance is reduced by about·10 per cent., which is the same thing as a reduction of c_w from 0.3 to 0.2.

D

Ahead of Their Time

INGENUITY IN 1910

Contra-rotating Airscrews with Metal Blades and Adjustable Pitch : Wings of High Aspect Ratio and Elliptical Plan Form : A Totally-enclosed Cabin

By THE EDITOR

LOOKING back on the early flying days, one is struck by the number of amazingly ingenious devices and ideas which many of our pioneer designers incorporated in their "flying machines." (Incidentally, why didn't we stick to that term? It is English and it is descriptive, which is more than can be said of the bastard concoctions that have since gained currency.) It was usually the case that the greater the number of "advanced" ideas in a given type the less likelihood was there of the firm making a financial success. That was but natural; most firms or individuals had small capital, and customers were few and far between, so that, unless a design could be pretty well guaranteed not to require many modifications, it was either not built or it "broke" its constructors.

One result of this was that many useful ideas either did not get beyond the drawing-board stage or they were seen in one example only, never to appear again. That was quite often due to features or circumstances unconnected with the special new feature. For example, many a useful machine was damned by a feeble and unreliable engine. I well remember that when the 50 h.p. Gnome rotary engine came along we thought we had almost unlimited power for a very low weight, and that engine removed flying from the "tangent" stage and made possible a reasonable speed range. For the purpose of our younger readers I might explain that the word "tangent" was used to denote an aircraft in which the power-required and power-available curves just touched one another, so that only at one particular speed would the machine fly; it had no speed range. In these days of 2,000 h.p. and 400 m.p.h. it will probably come as a surprise to many to learn that men did venture into the air in contraptions which were horribly underpowered and only flew because of their very light wing-loading.

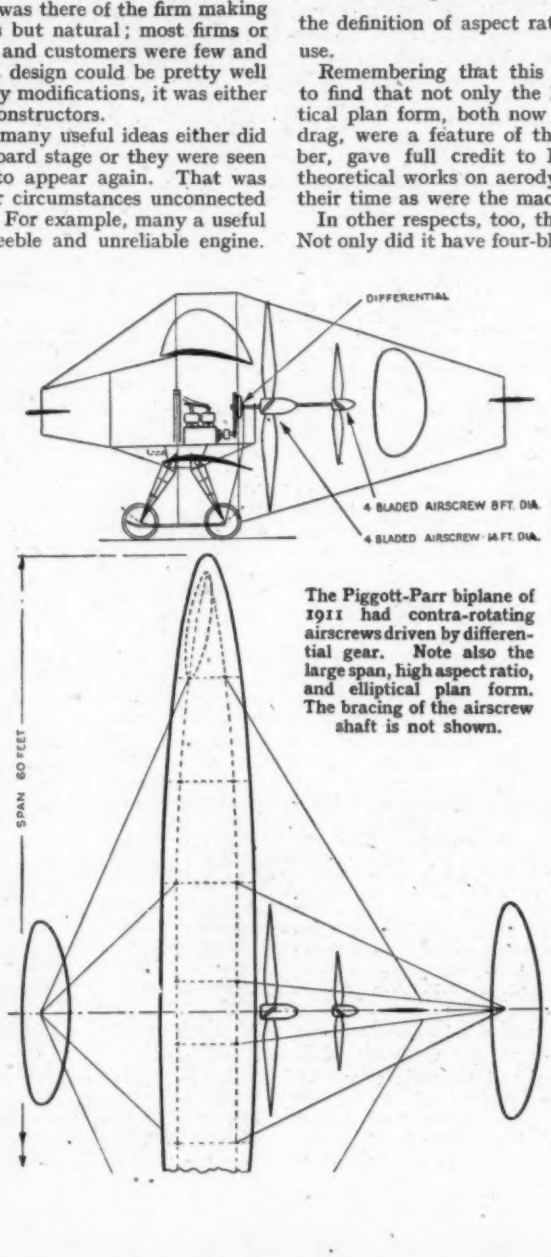
A reader, Mr. W. A. Woodward, has reminded me that in 1910 *Flight* published an illustrated description of a type of aircraft which had a number of features which one would hardly expect to find at that stage of evolution. The firm of Piggott Brothers and Co. built the machine, which was designed by their engineer, Mr. S. C. Parr

So far as I remember, the machine never flew. Very probably it never really had a chance to fly, but the designer was undoubtedly on the right track.

The Piggott-Parr was a biplane of 60ft. span, and the remarkable thing about its wings was that it had a chord of only 6ft. Remarking on this fact at the time, *Flight* said: "The aspect ratio is thus nominally 10, but the equivalent value of this ratio for an ellipse as compared with a rectangle is unknown." Apparently at that time the definition of aspect ratio as $\frac{\text{span}^2}{\text{area}}$ had not come into use.

Remembering that this was in 1910, it is remarkable to find that not only the high aspect ratio but the elliptical plan form, both now known to be conducive to low drag, were a feature of the design. Mr. Parr, I remember, gave full credit to Dr. F. W. Lanchester, whose theoretical works on aerodynamics were as much ahead of their time as were the machines designed to his ideals.

In other respects, too, the Piggott-Parr was remarkable. Not only did it have four-bladed, contra-rotating airscrews, but the blades were hollow and made of aluminium sheet, and the pitch was adjustable. In addition to the two airscrews being rotated in opposite directions, they were indirectly driven through a differential gear, so that they were self-balancing to the extent that if one absorbed less power than was intended, it would speed up and the other slow down until a balance was struck.



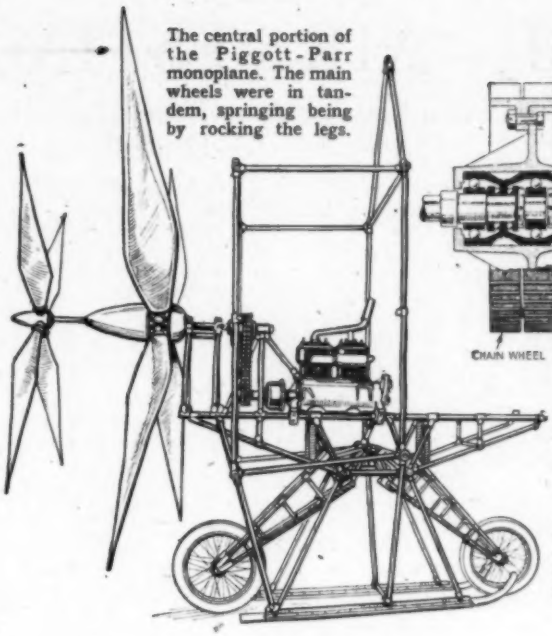
The Piggott-Parr biplane of 1911 had contra-rotating airscrews driven by differential gear. Note also the large span, high aspect ratio, and elliptical plan form. The bracing of the airscrew shaft is not shown.

Here, again, we see Lanchester influence. It may be recalled that in our issue of December 11th, 1941, we published an article by Dr. Lanchester in which we gave a drawing of a differential airscrew drive patented by him in 1907! It may be assumed that Mr. Parr was indebted to Dr. Lanchester for the general idea, although the details of the Piggott-Farr gear were somewhat different.

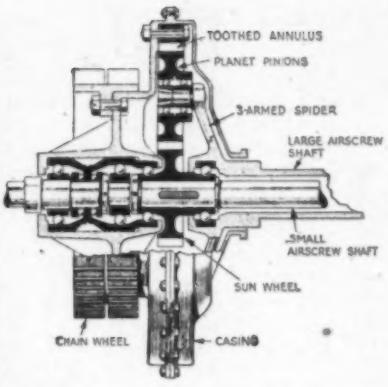
The two airscrews were chain-driven, the chain wheel being attached to the casing of the differential gear. The casing carried a toothed annulus which engaged with planet wheels carried on a three-armed spider. The sun wheel was carried on the end of the solid shaft of the smaller of the two airscrews. The spider was attached to the

tubular shaft of the larger airscrew. Details of the gear are shown in the sectional view.

From the general arrangement drawings of the machine it will be seen that the supports for the airscrew shafts were not shown in our drawings published at the time. The reason probably was that the details had not been worked out fully when the article was written. Obviously, the intention was to brace the shaft bearings to the tubes of the tail outrigger in some fashion, and deflections were certainly expected, for provision had been made to incorporate a flexible coupling, a section of which is given in another view. There is nothing very remarkable in the coupling itself, but an ingenious dodge is the single ball between the ends of the two portions of the shaft. This ball was intended to transmit the airscrew thrust from one portion of the shaft to the other, and would do so even if there should be a considerable "bend" in the shaft.



The central portion of the Piggott-Parr monoplane. The main wheels were in tandem, springing being by rocking the legs.



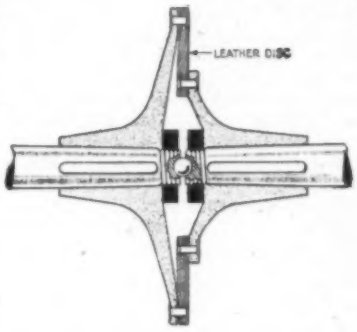
The section above shows the differential gears used in converting the chain transmission into contra-rotation. The lower section shows the flexible coupling which took care of deflections and misalignment of the shaft. Note the single ball which took the airscrew thrust.

It was not considered advisable to subject the large-diameter hollow airscrew blades to the sudden shocks of starting, and as a protection for them a multiple-disc clutch was incorporated between the crankshaft of the engine and the chain sprocket of the airscrew drive. Thus the engine could be started and run-up with the clutch out, and by careful manipulation the airscrew blades could be accelerated quite gently. That was a refinement not even found in modern airscrew drives.

Perhaps the reason, or one reason, for the failure of this machine to "make good" may be found in the weight figures. The engine developed 70-80 b.h.p. at 1,400-1,600 r.p.m.; the clutch weighed 56 lb. and the differential gear 55 lb., so that the transmission must have amounted, all told, to nearly 2 lb./h.p., not counting the weight of the two airscrews. But the details are interesting from an engineering standpoint. The Piggott firm broke new ground in quite a different direction in the following year.

The First Enclosed Monoplane

At the Olympia aero show, "1911," they exhibited what must have been the first British all-enclosed monoplane. A year or so later the Avro company came along with a biplane and a monoplane which had that feature, and both these machines flew, but the 1911 Piggott did not, I believe, leave the ground. Our photograph, taken at Olympia, shows the perfect streamline form of the fuselage, the large spinner which completed the form, and the very inadequate windows through which the pilot was to get his view.



In addition to the all-enclosed feature, the Piggott monoplane of 1911 was interesting in having what must have been the first "shaped" surface radiator. In the picture it is the little patch on the "forehead" of the fuselage. The engine was of 80 h.p., so that may explain the small area. In the Supermarine Schneider monoplanes the radiators occupied nearly all available area on wings, fuselage, and even floats.

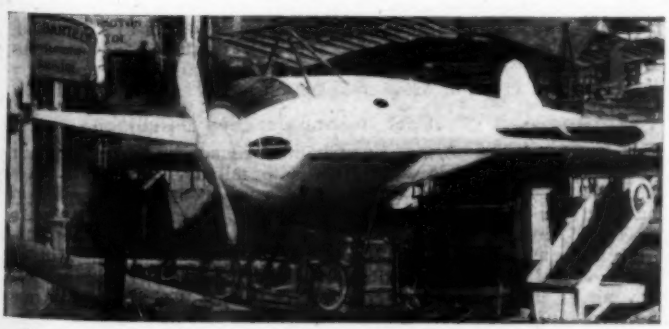
One thing the enclosed Piggott monoplane shared with its contemporaries: it had an undercarriage in which absolutely no attempt had been made at streamlining. The old pusher biplanes usually had two skids, sometimes long and sometimes short, each carrying a pair of wheels side-by-side, the short axle crossing the skid and being connected to it by a lashing of rubber cord. Two radius rods from skid to axle kept the wheels tracking fairly well.

The same arrangement was found on the Piggott, and at the time this appeared reasonable, although nowadays it looks somewhat incongruous when married to a fuselage of perfect streamline form.

Wing bracing was of the external type (the cantilever being regarded as far too heavy), and lateral control was by warping the whole wing. That was common practice in those days, especially on monoplanes. The biplanes were the first to adopt ailerons.

I do not know why the Piggott enclosed monoplane came to naught, but I remember that the rudder was diminutive, and I do not think there was any fin, so the machine must have been very unstable directionally.

C. M. P.



The first British all-enclosed monoplane. The Piggott was exhibited at Olympia in 1911. Perspex had not been invented then, else the windows might have been larger! Note the surface radiator on top of the fuselage.

THE AIR ESTIMATES

Sir Archibald Sinclair's Speech : New Fighter Types Foreshadowed : Work with the Navy and Army

THE Air Estimates were introduced into the House of Commons on Wednesday, March 4th, by Sir Archibald Sinclair, Secretary of State for Air. He said that during recent months there had always been a very substantial number of German bombers within easy reach of all the cities of this country. Since June the main task of the R.A.F. had been to give the utmost possible help to Russia. He said it had never been the intention that our fighter Wing should remain at Murmansk during the winter. Increasing numbers of our aircraft were working on the Russian front. We could not man them ourselves. It was not easy for us to spare them, but they were helping the Russians to maintain the air superiority which they now enjoyed on their entire front. By our agressive action from Malta, in Africa, and over France, we had kept a large number of German fighter squadrons facing west. In offensive fighting from this country during the last 12 months we had destroyed 823 enemy fighters for a loss of 537 of our own.

Work With the Other Services

The Air Minister then dealt with co-operation with the Navy and Army. It would not be appropriate, he said, for him to deal with the passage of the enemy warships up the Channel, but the Navy and Air Force together had virtually closed the Straits of Dover to enemy merchant ships, which had been no easy task. They had also driven the U-boats right out of the Western Approaches. Our East Coast convoys had been so well protected that between Harwich and Newhaven (the most difficult part of the Straits) they were coming through with clocklike regularity.

Bomber Command had kept three of the most formidable warships in the German navy ignominiously confined in the harbour of Brest while the battle raged outside. During the past year 40 per cent. of Bomber Command's total effort had been against targets which the Navy had asked it to bomb. The two Services had worked together willingly, loyally and effectively, and both were constantly striving to improve the methods of co-operation.

The main aspect of air operations in recent months had been co-operation with the other Services in the Middle and Far East. In spite of their extreme tactical mobility, air forces were not strategically mobile. The maintenance crews and equipment had all to be moved by sea. Nevertheless, we had sent large numbers of aircraft to the Far East and had taken extreme risks to get them there. We had lost some on the way, and many in heavy fighting, but reinforcements continued to arrive in that theatre.

Co-operation With the Army

In the Middle East during the six months preceding Gen. Auchinleck's advance, R.A.F. and naval aircraft had sunk some 175,000 tons of enemy merchant shipping in the Mediterranean. To send a ship to the bottom with 50 tanks on board was a big contribution to success in the land battle.

Continuing, the Right Hon gentleman said that to Hon. members who would show him how the co-operation between the Royal Air Force and the Army could be still further improved he would listen with respectful attention. He was sure it could still be improved. The word "satisfaction" was unknown in the Royal Air Force. They lived in an atmosphere of swift development and revolutionary change; they welcomed new ideas. But they most strongly deprecated that mischievous agitation which misrepresented the willingness of the Royal Air Force to work with its sister Services. Night after night at the proper behest of the Admiralty, crews flew into the world's heaviest anti-aircraft barrage at Brest. Night after night Bomber and Coastal Command crews had sallied out on dangerous expeditions—bombing, mining, reconnoitring, and photographing—and glad to help the Royal Navy win the battle of the Atlantic. It had been a poor reward for them to read that their work was being continuously disparaged, and to be told that they were stubbornly refusing to help the Navy, and that the Royal Air Force ought to be dismembered. So with the Army.

In the Middle East

The pilots and crews in the Middle East knew that their job was to do all they could to help the Army win its battles in the Western Desert. They were not sparing themselves. General Auchinleck had given them full praise. The success of the advancing Eighth Army, he stated, "would never have been achieved without the wholehearted co-operation of the Air Force, whose work has been magnificent throughout." But they had received other unsolicited testimonials to the effectiveness of the co-operation between the Army and the R.A.F. The following was an extract from the diary of a German officer: "The night was terrible, the English bombers came in force and dropped their eggs. We had no cover, not a hole nor a building, and when they had dropped their bombs they made low-flying attacks and shot us up. So it goes on night after night. In broad daylight the English fighters attack our motorised columns with success."

A captured German Army intelligence summary said: "On all parts of the front the enemy continues to have marked air superiority. Our own air reconnaissance has been considerably hindered." Another German intelligence summary said: "The enemy continues to have air superiority and his air forces are co-operating with his land forces with great effect." This work for the Army was dangerous. Royal Air Force pilots and crews did not grudge the risk, but when they got back and read in their newspapers that the Air Force was not out to help the Army, and that the squadrons they were proud to serve in ought to be handed over to the Army, they resented it deeply and bitterly. It was doing harm.

The Right Hon. gentleman continued: "The Commander-in-Chief in the Middle East and officers of the Royal Air Force at home have represented to me that unless this criticism is moderated and brought into some relation to the facts, co-operation between the Air Force and the Army will become less cordial. It makes for the very fault—ill-feeling between the Services—which it affects to condemn. . . . The Royal Air Force has beaten the Germans in every other form of air fighting, and it means to beat them at Army co-operation. Together with the Army we mean to go on getting better at it—not only in Africa but here at home. We are determined to improve the methods and efficiency of the squadrons in Army Co-operation Command. Substantial numbers of squadrons of Bomber and Fighter Commands are being constantly practised in Army co-operation.

Tactical Reconnaissance Squadrons

"The Army Co-operation squadrons, because their primary role is to train with military formations, have been deprived for the most part of the opportunities of meeting the enemy for which they are eager. I am glad to inform the House that, with the agreement of the Commander-in-Chief, Home Forces, these squadrons will be given an increased measure of reconnaissance activity over enemy territory across the Channel. The status of Army Co-operation Command is no whit inferior to that of the other three operational commands. They will have their share of the fighting, and we are now about to re-equip the tactical reconnaissance squadrons with aircraft of a new

type, which have been described to me as the best of the American fighters now in full production. A new arrangement has just been made to foster co-operation between the Services right from the bottom. All our young pilots and air crews who are trained in such great numbers oversea spend a little time at reception centres on their arrival back in this country. I have suggested, and the Admiralty and the War Office have readily and cordially agreed, that in future much of their time will be spent with the other Services. Our men will go to Army and Naval units and will live for a week at each before they go on again with their aircrew training. By this means at an early stage these young men will begin to think more and learn more about their sister Services.

Sir Archibald went on to pay a tribute to the defenders of Malta, which during the last two months had suffered 394 air attacks. The Hurricanes there were handicapped by the short warning they received.

New Fighter Types

The Air Minister then turned to the Empire training scheme, mentioning the various centres and telling the House that pilots trained in India had been in battle with the Japanese. He expressed gratitude to President Roosevelt for training facilities provided in the United States.

The Air Minister went on to tell the House that this year would see still further improvements in the Spitfire and Hurricane, while further new types, some of revolutionary design, were ripening. The Americans, who had given us the Tomahawk and the admirable Kittyhawk, were also going to send us dive-bombers. He recounted the successes of that type in Poland, Norway, Holland, Belgium, France, Greece and Crete, and also when used by the Japanese in Malaya and Singapore.

"The other side of the picture," Sir Archibald went on, "was that in the Battle of Britain the Stukas lasted precisely two days, after which, owing to the enormous rate of casualties inflicted on them, they disappeared completely from the battle. In Libya, in the campaign both last year and this year, the enemy had not used dive-bombers to any great extent, and when used they had caused remarkably little interference with the movement of our troops. The dive-bomber had been proved by experience to be an effective weapon only in a theatre where a complete or very large measure of air superority had already been gained. The Germans realised this, and the proportion of dive-bombers to the total bombing strength of the German Air Force had over the last two years been much reduced." Nevertheless, in June, 1940, dive-bombers had been ordered from factories in America and accordingly a type markedly superior to the Ju 87 would shortly be available.

The heavy bombers, Stirling, Halifax, and the Manchester, already emerging in a new, bigger and stronger form known as the Lancaster, were coming into service in increasing numbers. We intended to resume the bomber offensive against Germany on the largest possible scale at the earliest possible moment. We had suffered some disappointments in the delivery of aircraft, but the most important cause of our disappointments had been the weather, which since October had been bad for air operations.

Results of Our Bombing

The Air Minister then gave some facts about the results of our bombing. At Wilhelmshaven, out of eight U-boats due for launching by a certain date, only three left the slips; at Hamburg only three U-boats were launched instead of eight, and vessels of a type normally launched after two months had been seen still on the slips after three months. Aachen and Munster were certainly in a worse condition than Coventry and Plymouth. In many places in the Ruhr, in Wilhelmshaven, and Emden our photographs showed, to the expert examiners, areas devastated by our bombing. At Dusseldorf, in a recent attack after one of our heaviest bombs had been dropped, a whole built-up area, in the words of the pilot, "appeared to boil." There was steadily increasing material destruction; while neutral and independent observers agreed that the compulsory retirement to shelters had told on the *moral* of the German people and had slowed down production.

We had not had all the aircraft we wanted. The set-back in British production had been mainly the result of German bombing. Not only the direct result, which was not negligible, but the indirect result—the adoption with ruthless energy by Lord Beaverbrook of the necessary policy of dispersal. We knew from bitter experience in this country that even ill-directed and ill-planned bombing produced serious effects on industry. The effects of our bombing on Germany had also been serious—light in scale as it had been compared with our own plan. And the increase in our bombing power did not depend only on numbers of aircraft and weight of bombs. As tactical and technical methods developed, in spite of the developing German defences, we were able to drop our bombs with increasing accuracy. As new bombs became available, a given weight produced increasing destruction.

Sir Archibald said that the talk about the futility of bombing was dangerous. He then went on to give some account of the bombing of the Renault works near Paris the night before, which, he said, did not indicate a change in policy—only a change in the weather. He ended with a glowing tribute to all members of the Royal Air Force.

The Debate

MR. GARRO JONES criticised the Air Ministry's bombing policy, and suggested certain priorities: first, adequate fighter defence of this country; second, full equipment of a comprehensive Fleet Air Arm in all main theatres of naval war, to include shore-based reconnaissance machines, torpedo-bombers, and long-range fighters when necessary. The third priority would be air units for each division or corps of the Army. Lastly, bomber fleets should be divided according to strategic requirements in the main theatres of war, with not more than 500 in this country.

REAR ADL. SIR MURRAY SUETER criticised the co-operation between the Army and the Air Force, quoting a case mentioned by Sir E. Makins, M.P. He asked why the Japanese had more powerful air torpedoes than we had.

MR. MANDER urged that the Air Force should take over the A.A. defences from the Army. He rather deprecated dive-bombers, but approved the policy of heavy bombing.

MR. EMMOTT believed that the Army did not really want its own air arm. What it wanted was more air support—quite a different thing. He asked what the Army Co-operation Command was doing.

CAPT. PROFUMO said emphatically that the present system of co-operation between the R.A.F. and Army needed to be completely reorganised. For long enough the so-called army co-operation had been the Cinderella of the R.A.F. He was not in favour of a separate Army air arm.

MR. DUCKWORTH agreed with Capt. Profumo, and spoke from his own experience in A.A. during this war of the difficulties in practice in securing really effective co-operation between two separate Services, wearing different uniforms.

CAPT. PETER MACDONALD thought that the feelings of the Army and the R.A.F. were not intimate enough. He was not in favour of a separate air arm for the Army, but closer relations were needed. He, too complained that nothing had been heard about the Army Co-operation Command in the R.A.F.

MAJOR MARLOWE insisted that an Army commander should have complete responsibility for the operations of aircraft working with his force.

CAPT. PLUGGE did not want squadrons transferred from the R.A.F., but wanted the Army to build up its own air arm.

SQN. LDR. FLEMING opposed "dismembering" the R.A.F.

SIR ARCHIBALD SINCLAIR replied to the debate.

BEHIND THE LINES

Service and Industrial News from the Inside of Axis and Enemy-occupied Countries

Oerlikon Expansion

THE activities of this company, famous for its machine-guns, are rapidly expanding also beyond the frontiers of Switzerland. A new plant has been established in Spain and another one in occupied Belgium. In February the company started the production of aircraft in a new factory situated on the Vierwaldstaetter-Lake (Switzerland).

In Search of Fuel

A NEW addition to German Oil Companies is the Lower-Danube Petroleum Company, recently registered with a capital of one million RM. A concession granted to the company authorises the prospecting and exploitation of petroleum and oil products within the territory of Lower-Austria.

From previous geological surveys of this region it appears doubtful whether the activities of the new company will make any serious contribution to Germany's fuel supply.

The Dorniers

THE Dornier Do 217 twin-engined bomber was described in *Flight*, February 12th, 1942. Here are some further details:—

Span, 72ft. Length, 63ft. 5in. Wing area, 830 sq. ft. Empty weight, 16,800 lb. Normal useful load, 12,050 lb. Maximum useful load, 18,020 lb. Gross weight, 30,850 lb. and 35,000 lb. respectively. Normal wing loading, 36.5 lb./sq. ft. Normal power-loading, 13.2 lb./h.p. (6 kg/c.v.). Performance figures claimed are: Maximum speed, 294 m.p.h. at 19,000ft. Cruising, 200 m.p.h. Range at maximum gross weight, 4,500 miles.

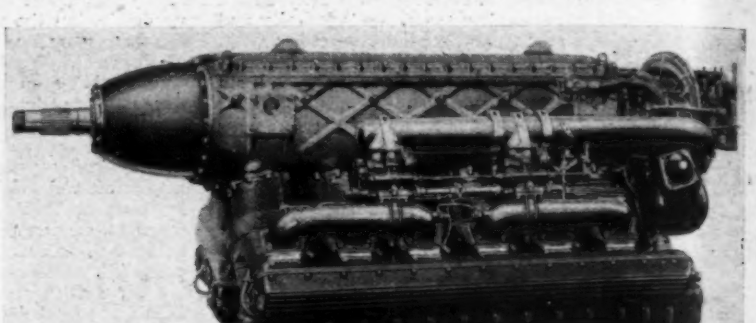
Do 17z

IT seems that the production of the Do 215 twin-engined bomber, which was powered with 12-cylinder liquid-cooled DB engines of the type DB 600 of 1,050 h.p. or DB 601 of 1,150 h.p., or DB 603 of 1,300 to 1,500 h.p., has been abandoned in favour of a model *Do 17z* which differs from the above by the use of *Bramo Fafnir* 9-cylinder air-cooled radials of 1,000 h.p. This type has also a slightly lower empty weight than the Do 215 (11,500 lb., against 11,680 lb.) and a greater useful load.

Empty weight, 11,484 lb. Gross weight, 18,931 lb., or, with longer take-off run, 19,481 lb. Normal equipment and armament, 1,661 lb. Movable equipment and ammunition, 99 lb. Fuel, 4,015 lb. Oil, 242 lb.

Crew of four.

Bomb load, five or, exceptionally, ten bombs of 110 lb. each, making 550 or 1,100 lb. Two bombs of 550 lb. each or, if desired, 20 bombs of 110 lb. each may be carried as an alternative for short-range operations where, of course, less fuel supply is needed.



ISOTTA-FRASCHINI ENGINE "GAMMA": One of the recent developments of the Italian aircraft engine industry. It is an air-cooled, supercharged, 12-cylinder vee engine. Rated power 1,600 h.p. Take-off power 1,700 h.p. at 2,200 r.p.m.

Nazi Dispersal

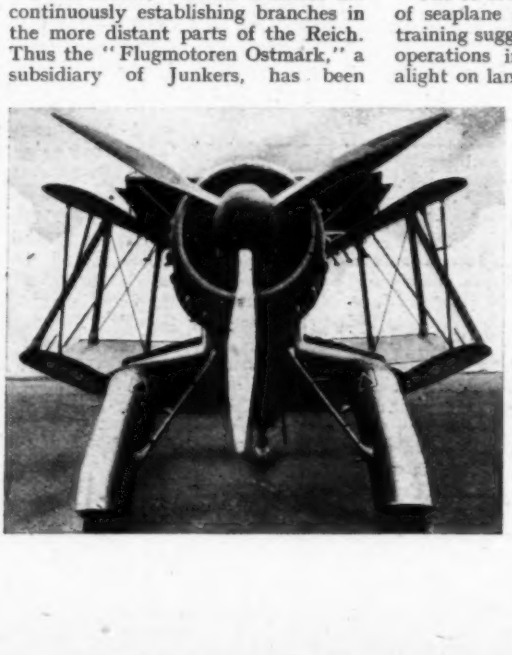
THE German aircraft and accessories industry is sparing no efforts to disperse production over the entire Reich, and in particular to establish new enterprises in such regions which are considered less vulnerable to air attack. An important part of this policy is the reorganisation of the aircraft industry taken over in the occupied countries. In Rumania, Czechoslovakia, Poland *and* Italy the aircraft industry has been stiffened up by the despatch of German experts, organisers and foremen.

Furthermore, German factories are continuously establishing branches in the more distant parts of the Reich. Thus the "Flugmotoren Ostmark," a subsidiary of Junkers, has been established in Vienna for the production of aircraft engines; the Junkers works in Erfurt are now engaged in the production of fuselages. The Daimler-Benz and the Deutsche Benzinuhren (Instruments) have both established production branches in Alsace. The well-known wireless equipment manufacturers, Friesecke-Hoepfner, have a plant operating in Lower-Silesia, and the Heinkel Company has a branch in Poland.

Sea-going Gliders?

ACCORDING to reports in the Portuguese Press, seaplane gliding is being reorganised in Germany and placed under the direction of Jachtmann, a prominent member of the N.S.F.K. (National Socialist Air Corps). Jachtmann is one of the pioneers of German amphibious gliders.

The co-ordination of the production of seaplane gliders and the intensive training suggests plans for some future operations in which gliders able to alight on land or sea may be used.



STILL IN SERVICE: The Arado A.95 general-purpose biplane with a trousered undercarriage with folding wings. Power plant: one 880 h.p. B.M.W. 132 Dc nine-cylinder radial air-cooled engine, enclosed in long-chord cowling, with leading-edge exhaust-collector ring. Another version is used as a bomber-torpedo-reconnaissance catapult seaplane.

HERE AND THERE

Production With a Vengeance

ACCORDING to *Aero Digest*, Northrop has orders for $34,000,000 worth of Vultee Vengeance dive-bombers for the R.A.F., and the first one recently left the production line.

Recording its emergence from the factory, the statement is made that "eight months were required to tone up and prepare for production of the Vengeance."

Indian Air Force

THE decision to expand the Indian Air Force to ten squadrons from the present three is announced in a recent issue of the *Civil and Military Gazette*, published in Lahore.

"There are twenty times the number of officers and seven times the number of airmen in the I.A.F., as compared with those at the outbreak of war," says the report, "and these numbers are going up considerably."

A school for technical training has been formed and its output is now said to be 600 men per annum.

Holidays in 1942

RECENT announcements by the Government on holidays during the present year stipulate that in order to continue the national effort at full stretch, the customary holiday, so far as it does not exceed one week, should be taken, and there should be for most workers in the aircraft and other vital war industries a one-day break on Easter Monday, Whit Monday and August Bank Holiday, with two days at Christmas or the New Year.

There should, however, be no cessation of work on Good Friday, and the Government expects that workers receiving the prescribed holidays will be regular in their attendance at work at other times and will not extend the holiday period or absent themselves from work at other times.

Art in the Services

MORE than 2,000 exhibits, including drawings, paintings, sculpture and models, have been entered for the Forces' Art Exhibition, which opened in the National Portrait Gallery on Tuesday.

That they are truly representative of the Allied Nations is shown by the fact that, in addition to Home Country entries, exhibits have also been received from the Canadians, from the American Ambulance Unit, the Free French and from the forces of Czechoslovakia, Poland, Norway and Luxembourg.

Many well-known artists are contributing, among them W. T. Wood, R.W.S., R.O.I., Charles Ffoulkes, C.B., O.B.E., Albert Perry, Col. J. J. H. Nation, Jean Oberle (France), Capt. Oktawican Jastrzembski, and Flt. Lt. Horowicz (Poland).

Canada has its own gallery in the exhibition, which has among its patrons the Canadian High Commissioner, Mr. Vincent Massey, and General A. G. L. McNaughton, and a separate gallery is also given over to some 500 entries from the Forces in the London district received by the Y.M.C.A. in its recent competition.

"A VERY GALLANT GENTLEMAN": Lieut. Commander E. Esmonde, D.S.O., R.N., who led the six Swordfish against the German warships in Dover Straits and was posthumously awarded the V.C., is here seen in the uniform of Imperial Airways (forerunner of British Overseas Airways) whom he served from 1934 until he joined the Fleet Air Arm in May, 1939. He joined Imperial Airways after five years in the R.A.F., flying Atlantas and Hannibals in India and the Far East, and in 1938 he captained Empire flying boats. The official citation appears on page 243.

Is There a "Spider Club"?

CAN any reader of *Flight* supply information on the existence or otherwise of "The Spider Club"—membership open only to aircrews who have hit a balloon cable and got away with it?

The Caterpillar Club for those who have saved their lives by "brollie," and the Late Arrivals Club for airmen who have managed to return to base on foot (emblem, a winged boot) are well known, but the Editor of *Flight* has received an enquiry from a potential member of the Spider Club and would like to pass on the name and address of the secretary, if any.

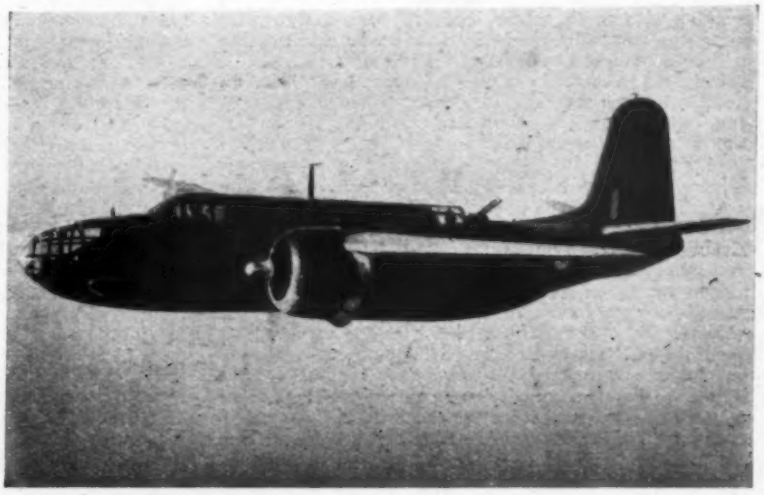
A sergeant pilot stationed in the north recently collided with a balloon cable, and after what he modestly describes as "plain luck," he managed to pull off a dead-stick landing with yards of cable tangled round the airscrew, he and his gunner being unhurt although the aircraft was decidedly bent in several places. He says he has been told there is in existence an organisation known as the Spider Club, for just such lucky people as himself and his gunner, and, if there is, he wants to get into touch with its secretary.

Brush Board Changes

SEVERAL changes have taken place in the board of The Brush Electrical Engineering Co., Ltd., at Loughborough, and of subsidiary companies.

Mr. T. B. Keep, M.I.Mech.E., has retired from the board, but is remaining on the boards of two subsidiary companies, namely, Brush Coachwork, Ltd., and Petters, Ltd. Mr. Alan P. Good, deputy chairman of the parent company, has been appointed managing director in succession to Mr. Keep, and Mr. M. A. Fiennes has joined the board as an executive director.

Mr. W. M. Good, A.C.A., has been appointed managing director of Brush Coachwork, Ltd.



DESERT HUN-STRAFER: A Douglas Boston III of the South African Air Force in flight over the Libyan desert. This is one of the first pictures of the Boston showing the twin guns for defence against attack from the rear.

Topics of the Day

TWO-DIMENSIONAL

"Indicator" Discusses Film Production and its Vital Usefulness Where Flying is Concerned

As one who has a natural bias against practically all "modern" entertainments and pseudo-"modern" ideas—from tinned peas to tinned music, and from the jitterbug to the sort of long-drawn-out jittertalk one hears endlessly on the radio—I might be expected also to have one against the cinema. In fact, any bias I hold is really against principles rather than things; one doesn't appreciate music if one can turn it on and off at will from an armchair, and peas tend to lose their taste if they are tinned.

I like the cinema, and I think it has tremendous possibilities if its particular advantages are properly exploited. As a sort of two-dimensional second-hand portrayal of plays, these possibilities are largely wasted; when ordinary human characters are the focal points in any film, the stage play can do just as well (with an added advantage in reality), and the cinema merely permits unlimited reproduction and distribution—in fact, the "tinning" of art. But Mr. Disney has shown, and continues to show us, the sort of uses to which the two-dimensional, sound-tracked, tinned stage can be put. I believe that Disney and his competitors really *have* got something, both for educational and other purposes.

Non-flying Producers

Amongst many other quite exclusive uses to which the art of film production can be put is that of giving the public a really true and faithful picture of flying and flying people. By no other means can it really be described, or the sensations and sights be reproduced. Neither pictorial nor verbal art can do the job properly.

Perhaps because the average pilot is neither a writer nor an artist, and because these two rarely have the kind of temperament needed in a pilot, there have been surprisingly few good books written about flying and surprisingly few pictures painted or drawn which really convey the true impressions of flying. The film is a medium which could be used more and more successfully, and both dramatic and documentary films—provided they are produced with care and realism—would be almost certain winners. People are interested in flying—and they always have been interested. It is something new and exciting, something with an almost unlimitable future, and it never seems to me that film producers have made much of the tremendous number of opportunities available.

During the last ten years or so there have been an incredibly large number of really bad pictures dealing with flying, relieved by depressingly few good ones.

The other day, when I saw a film called "The Little Foxes," and marvelled at the effort put in to make it absolutely perfect as a 1900 period-piece, I wondered why the same effort could not have been applied to the production of every flying film.

Even the good flying films, few though they are, have usually been partially spoilt either by minor technical errors or by the frank unreality of the story. In some cases the former have not been blatant enough to be obvious to the G.B.P. (Great British Public to you), but the actions and reactions of the participants have so often been guided by what the non-flying producers have imagined to be those of airmen in general. These same producers will *not* realise that to the average pilot peacetime, or even wartime, flying is merely a job of work and nothing to be particularly frightened or hysterical about.

Flying, now that aircraft are so very complicated, takes rather more out of one's nervous system than other professions, and war flying is certainly liable to give anyone the jitters, but pilots do *not* behave always on "let us eat, drink and be merry for to-morrow we die" lines. That sort of thing spoilt an otherwise excellent peacetime film—"Test Pilot." The flying in this was probably more technically perfect than in any other previous film, but the whole effect tended to be spoilt by the over-hysterical scenes between the hero and his wife. All the nonsense about the "little lady in the powder-blue dress" (or whatever it was) who would "get him" in the end was just not true to life. People—even the most neurotic flying people—do not behave like that or talk like that.

In all operational squadron messes there is perhaps a trace of the "Dawn Patrol" atmosphere, but, if a film is to be made, this atmosphere must not be exaggerated; it is something a visitor *feels* rather than sees or hears as actual evidence. I was not particularly impressed by "Target for To-night" as a flying film, but I was most impressed by the ground shots and the very excellently correct impression in the operations and crew rooms. The atmosphere was absolutely right.

Various views have been expressed about a more recent film—"Ships with Wings." Certain stupidities were allowed to get by, but here again the atmosphere was impressively naval and British, and the pilots' private lives were not allowed to interfere with things in general. A producer might not, in a peacetime picture, have been able to resist the temptation to introduce some triangular drama in the middle of a battle (complete with jealousy, and a villian doing absurdly unsporting things at critical moments), or even to permit a female to be sharing the captain's bridge on an aircraft carrier while real bombs were falling all round the place.

Model Films

Although there was inevitably a large amount of faking, this faking was so extraordinarily good and merged into the "real" shots so very well, that no possible exception could be taken to it. I don't think I have ever seen such remarkably good model work, whether of Mediterranean landscapes, warships, or aircraft, or such excellent "merging" and superimpositions. At no time was one's attention distracted from the story by obvious unreality; if there were any unrealistic model scenes, the producer had been clever enough to introduce them at moments when the audience's excitement was high, or to sandwich them between actual shots, taken in peacetime, of the real thing.

As a producer, I think I would have tried to find a better way of blowing up the dam than that actually used. For the benefit of those who didn't see the film, it should be explained that a Fulmar was flown on to the back of a bomb-laden German-Italian aircraft and the pair directed (in a grossly unairworthy condition, and through the Fulmar's own controls), on to the dam. We can forget, perhaps, the separate facts of the impossibility of the feat and that the bomb load would not be likely to go off unless the enemy pilot had already fused them in readiness. The G.B.P. might not even know that a fighter with its undercarriage down could not possibly catch a fast medium bomber. But, on the principle that it is not possible to fool all the people all the time, every member of the G.B.P. must have criticised one or other of even those three little points unless the undoubted excitement of the finale reduced everybody's critical faculties to zero.

It is not particularly helpful to talk about past mistakes in anything, but I feel very strongly that the art of film production can be made to do more for and with flying than any other. As I've said before, neither verbal nor pictorial art can do the job properly, and the world in general still needs to be educated and "enthused" before flying can come into its own in a peacetime world.

"INDICATOR."

Twenty-ninth of the Second Series

FRIEND or FOE?

Italian and U.S. Fighter-bombers: Breda-65 and Vengeance

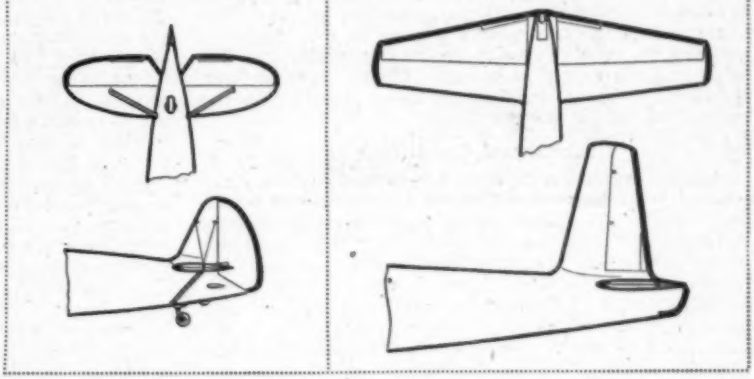
BREDA-65: Curved trailing-edge to rudder. Oval tailplane, with V-shaped "bite," is braced by strut below and wires above. Fixed tail wheel.

DESIGNED for use either as a single-seater fighter or a two-seater light-bomber, the Breda-65 has an approximate "opposite number" in the Vultee Vengeance which is now in production for the R.A.F.

The Italian machine is somewhat smaller than the Vengeance, about which particulars are as yet rather scanty, but their general lines are very similar, both being low-wing monoplanes with oval-sectioned fuselages and radial engines. Once again, however, they differ quite noticeably in their tail units, so that a rear view offers particularly good opportunities for identification.

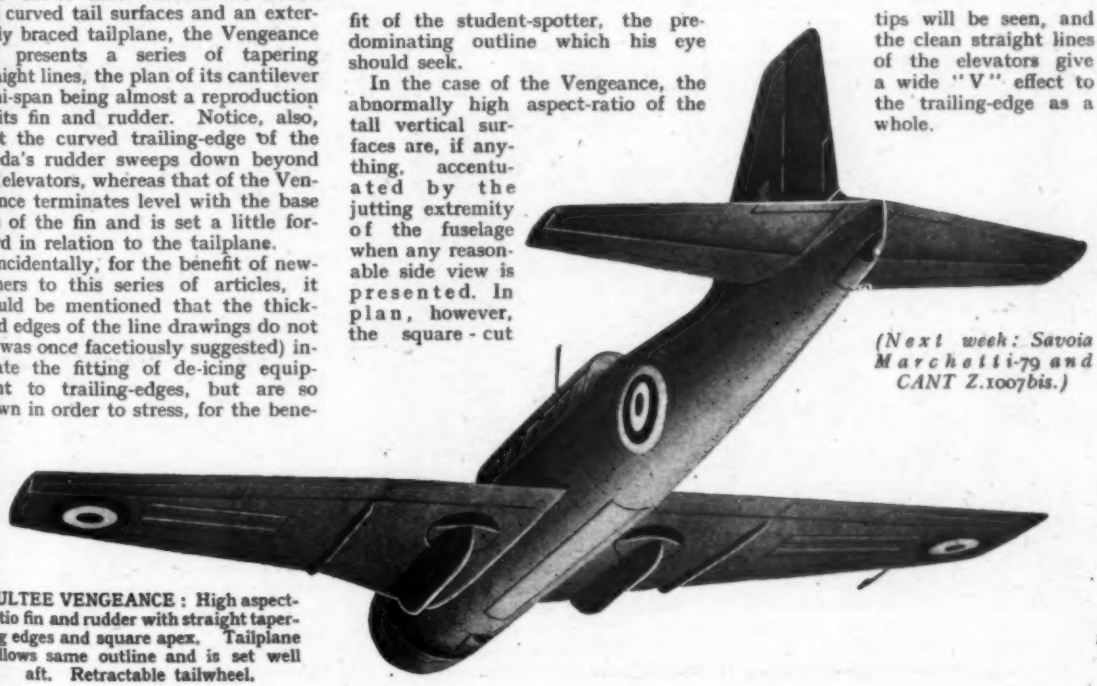
A comparison of the accompanying illustrations—especially the line drawings—shows that whereas the Breda has curved tail surfaces and an externally braced tailplane, the Vengeance tail presents a series of tapering straight lines, the plan of its cantilever semi-span being almost a reproduction of its fin and rudder. Notice, also, that the curved trailing-edge of the Breda's rudder sweeps down beyond the elevators, whereas that of the Vengeance terminates level with the base line of the fin and is set a little forward in relation to the tailplane.

Incidentally, for the benefit of newcomers to this series of articles, it should be mentioned that the thickened edges of the line drawings do not (as was once facetiously suggested) indicate the fitting of de-icing equipment to trailing-edges, but are so drawn in order to stress, for the benefit of the student-spotter, the predominating outline which his eye should seek.



In the case of the Vengeance, the abnormally high aspect-ratio of the tall vertical surfaces are, if anything, accentuated by the jutting extremity of the fuselage when any reasonable side view is presented. In plan, however, the square-cut tips will be seen, and the clean straight lines of the elevators give a wide "V" effect to the trailing-edge as a whole.

(Next week: Savoia Marchetti-79 and CANT Z.1007bis.)



VULTEE VENGEANCE: High aspect-ratio fin and rudder with straight tapering edges and square apex. Tailplane follows same outline and is set well aft. Retractable tailwheel.

MAN VERSUS ALTITUDE

The Human Aspect of High-altitude Flight : Physiological and Psychological Effects of Conditions at Great Heights : Experiments and Tests : Summary of Research

By Dr. V. L. GRUBERG

THE basic condition of modern air warfare is the efficient employment of high-performance aircraft and of a skilled and capable flying personnel. Since high-altitude flying offers definite technical and operational advantages, its application to air warfare is constantly and rapidly growing. This push into the upper regions of the universe, while gaining momentum under war conditions, unfolds new problems which have to be solved if man himself is to keep pace with his technical progress.

The problems are legion. One of them is the efficiency of a crew subjected to the influences of higher altitudes. Flying at a speed of some 200-450 m.p.h. with engines roaring with 500-2,500 h.p., the pilot has to control the flight and at the same time to concentrate on his operational duties. The observer, wireless operator and air gunner have to operate their complicated instruments and weapons and to be in a state of constant vigilance. All this at altitudes of anything between 18,000 and 35,000 ft. and higher, where the temperature is some 60 deg. F. below zero and life itself can be maintained only with the help of an artificial supply of oxygen. Clearly, such working conditions differ profoundly from those prevailing in the lower strata of the atmosphere.

Abnormal Conditions

Modern aircraft development has certainly relieved the pilot of many hazards and difficulties experienced in the old types and even allows him to relax temporarily during the flight. Yet, since man is essentially a "ground-bound" being, there is an enormous discrepancy between conditions of life in his normal surroundings and those at the higher altitudes. To bridge them and to bring them into harmony with the limitations and endurance of the human body is the unconditional qualification of a sound technical progress. Indeed, technical development extending beyond human physical and physiological endurance would be utterly meaningless.

Modern research is therefore unceasingly investigating the human aspect of high-altitude flight with the view to co-ordinate it with the technical progress.

The relative composition of the air at altitudes up to some 45,000ft. remains essentially unchanged and is 21 per cent. oxygen, 78 per cent. nitrogen, some 0.03 carbon-dioxide and about one per cent. of inert gases of which the chief is argon.

For the smooth working of the human machine, oxygen is the most vital necessity. Without an adequate and suitably rated oxygen supply the human body cannot exist, and since the reserve of oxygen in the body is very poor (approximately 400 cc. or enough to maintain life for 1½ minutes) a permanent supply becomes a necessity.

Effect on the Body

Oxygen is a permanent component of the atmospheric air and is subject to a code of behaviour common to all gases as formulated by Dalton. The effect of gases in the body varies with the pressure they exert. If there are several gases, the fraction of the total pressure exerted by each one of them is called the "partial pressure." According to Dalton's Law of Gases the partial pressure of a gas is equal to that which it would exert if it occupied the whole of the space alone. This partial pressure is expressed in terms of mm. Hg. (Mercury Column) and can be calculated from the percentage of a gas in the total pressure, viz., since oxygen represents 21 per cent. of the atmospheric air (or around 1/5th) its partial pressure in the atmospheric air is 160 mm. Hg.

To keep the human body in "running order" an adequate supply of oxygen at *normal partial pressure* is necessary because the vital parts of the human machine are only able to function by the combustion of food and the oxygen carried by the blood stream to the cells of the body. For the saturation grade of the blood pigments, the partial pressure of oxygen is decisive. The point at which the blood comes into contact with the inhaled air (and therefore with oxygen) is the lungs, and the pressure of oxygen on this point determines the binding capacity of the blood.

Under normal conditions we have the following situation: the partial pressure of oxygen is round 160 mm. Hg. while in the lungs it is only 100 mm. Hg. because of the presence of a water vapour pressure of 47 mm. Hg. and CO_2 pressure of 40 mm. Hg.

The higher the altitude the lower the atmospheric pressure and, as a result, the partial oxygen pressure. But the reduction of the partial oxygen pressure in the lungs is even more intensive, since under the strain of the altitude there is an increase of the percentage of CO_2 and water vapour in them. From Table 1 it can be seen that while atmospheric oxygen pressure is reduced by one third, the lung oxygen is dropped by half; this causes a slow diffusion of the gas into the blood and prevents a thorough saturation of the blood pigments, resulting in a strain on the cell tissues of the body.

Needless to say, this reduction of the partial pressure of oxygen has a

IN TRAINING FOR THE HIGHER ALTITUDES: Equipped with oxygen masks the crew exercises mildly to de-nitrogenise their bodies.

very negative influence on the human being and causes a complex of physiological and psychological symptoms known as *Anoxemia*. To start with, the affected person does not experience any harmful sensation at all; on the contrary, the more one is affected the better one feels—a queer and therefore dangerous state which can be compared to alcoholism. Characteristic of this state is the complete absence of the critical sense, incapacity to perform simple and accustomed manual and mental functions, lack of co-ordination and control of the body; indeed, a real disintegration of the personality.

It would be most unfortunate if a pilot responsible for his crew and aircraft, an observer or gunner, should start showing such symptoms in mid-air. Well known is the case of an air gunner who during a combat against an enemy craft climbed into his hatch and violently waved to his opponent.

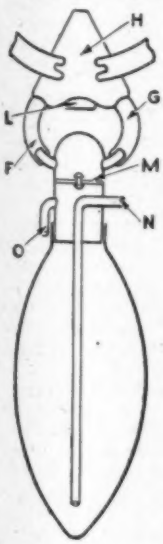
Automatic Readjustment

Up to a certain point the human body can help itself by intensified breathing, quantitative increase of the blood flow and increased heart action. In an aircraft cabin the inhaled air, however, is partly mixed with the exhaled carbon dioxide, which clearly does not improve the position. Indeed, this bodily exertion to readjust itself to the oxygen want, and to recover from it, is limited in its efficiency. At an altitude of about 18,000ft. intensified breathing cannot compensate oxygen deficiency for more than 15 to 30 minutes, nor raise the oxygen above 36 mm. Hg. Moreover, in doing so, the bodily effort is such that new symptoms of fatigue develop. In other words, it is a vicious circle; the body attempts to compensate for its oxygen deficiency, strains its mechanism to a maximum, and a new set of fatigue symptoms sets in. Known as *Acapnia*, this fatigue is the direct result of hyperventilation, which washes out the carbon dioxide in the blood. Once this has happened the main stimulant for respiratory functions is gone, and normal automatic breathing is likely to stop at once.

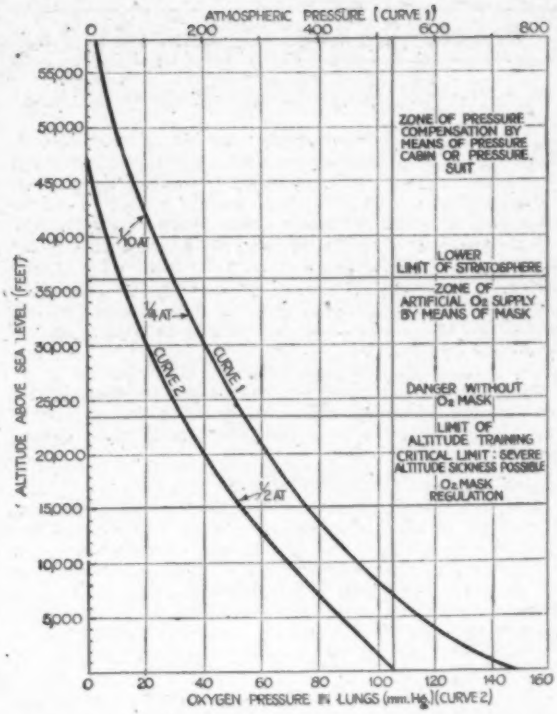
Nevertheless, the capacity of the human machine to readjust itself, even to a very limited extent, to the new conditions prevailing at higher altitudes is an important asset; for even with such technical equipment, which is to-day standard for high-altitude flight, the inert resistance of the body may be of greatest value in an emergency. This is particularly true of operational air combat flights where sudden changes of altitude or defects in equipment may force the crew to rely on their bodily resources in adapting themselves to changed conditions.

Just how long one can withstand *Anoxemia* depends largely on the peculiarities of each individual case. Various experiments show that in fit condition a man's resistance against oxygen want at 15,000ft. can be more than one hour, at 20,000ft. less than half an hour. Such experiments have established that the effect of oxygen deficiency is a function of time and intensity. This means that the effect of oxygen want is not only in proportion to the altitude but to the time spent under such conditions. In fact, tests conducted by the Materiel Division of the U.S. Air Corps show that flights of long duration at altitudes lower than 18,000ft. have produced a profound fatigue which necessitated 48 hours for recovery.

In operational combat flight a rapid reduction in the surrounding pressure



THE MARGARIA OXYGEN MASK: Composed of a mask for the nose (H), exhaling valve (L); N=oxygen feeder connection, M = inhaling valve for oxygen.



THE THREE ZONES OF ALTITUDE FLIGHT: The graph shows the reduction of atmospheric pressure and the corresponding oxygen partial pressure in the lungs. Compiled from research data obtained by Boothby, Lovelace, Benson and v. Diringshoven.

may cause severe auricular pains, and *Aero-Embolism*, which is similar to "Divers' bends." The effect of this sudden drop of atmospheric pressure on the human body may be compared to the opening of a bottle of champagne: the gases dissolved in the blood system bubble out and clog, by a foaming effect, the delicate tissues in the lungs and in the brain. To prevent it, high-altitude flyers de-nitrogenise themselves, i.e., exercise mildly for half an hour or so before their flight in order to wash atmospheric nitrogen out of their blood.

In order to ascertain the crews' ability to withstand high-altitude strain and to measure their mental and physiological reactions to high-altitude changes, aviation medicine has devised a number of interesting tests.

In the Test Chamber

In these tests, a chamber especially designed to allow controlled air-pressure changes reproduces the effects of conditions at the higher altitudes. Air pressure in the chamber is being continuously altered to represent air pressure at different altitudes. Thus, in the tests conducted by the Physiological Institute of the University of Zürich, air pressure was altered after 10 minutes to represent some 15,000ft. with a 7- to 10-minute stop at that "altitude," then after two minutes to 18,000ft., and a 7- to 10-minute stop and altered further to 22,000ft. with a stop of 8 to 15 minutes; thereafter "descent" to 18,000ft. where a 10-minute stop is made, and further to 15,000ft. with the same stop.

While in this chamber the future high-altitude flyer is carefully watched, his blood pressure and pulse measured at each "height" and his heart functions supervised. At the same time observations are made of his reactions, mental capacity, psychological condition, motility and sensibility. Thus at various "heights" the testee is asked to write his name, figures, and some such

MAN VERSUS ALTITUDE

simple phrase as "Air Ministry," or make simple calculations.

The results of the writing tests are indeed very interesting. In investigations conducted by the above-mentioned Institute about 40 per cent. of the tested men showed at about 20,000ft. "altitude" a temporary trembling and involuntary movement of hands (v. Tavel). In some cases these disturbances were so intense that they incapacitated the tested man from further writing. It was also found that there is a distinct tendency for involuntary repetition, particularly striking in hand-writing tests of educated and normally intelligent men subjected to conditions of 20,000ft. altitude.

In judging the results of the tests, allowance has to be made for the absence of the "responsibility factor," the lack of the danger element, and the fact that the tested man is aware of being on the ground and not in control of an aircraft.

Test Reactions

The reactions to these tests naturally differ from one individual to another. Only by a very careful co-ordination of psychological and physiological test results can a comprehensive picture be obtained of the possible behaviour of the pilot under real high-altitude conditions. It is of interest to note that the examined is in most cases completely unaware of the loss or diminution of his mental capacity and control, and usually views with surprise his twisted handwriting.

It is, of course, impossible to state definitely the fitness for high-altitude flying from one test. The background, character, past habits of life must be studied, and the test repeated to obtain correct results. But experience has shown that there are certain symptoms frequent with most "unfit" cases: temporary disturbance of sight and speech, hallucinations and apathy. Physically trained men, and those accustomed to mountaineering, as well as matured men with considerable flying experience, have shown better high-altitude adaptability than young and perhaps keen capable pilots.

It has also been found that a correct diet and sound digestion improve altitude adaptability—a fact still very much under-estimated in aviation circles.

Importance of Diet

While no diet can compensate for the oxygen deficiency, the meal which the crew partakes before flight can increase or decrease their "ceiling." Beans, peas, etc., and other gas-forming foodstuffs should be avoided. Furthermore, some food substances, such as fats, require more oxygen to oxidise them to carbon dioxide and water than others. If, therefore, a pilot's diet, and in particular the meal before his flight, is composed mainly of fats, his body burning more fat will be more susceptible to the strain of oxygen deficiency. On the other hand, carbohydrates, since they require less oxygen for their combustion, cause less strain on the body combustion process. It may, therefore, be suggested that a diet rich in carbohydrates (sugars) may to some extent improve the "ceiling" of the high altitude of the crew.

To create a further source of quickly available energy it is suggested that both before and during the flight the crew should be given some quantity of glucose. The sugar which supplies the body with energy is glucose. In normal diet it is taken in complex substances, such as starch, etc., and has to be broken down to glucose, which is then burned by the body. If glucose *itself* is taken, in ready-made form, it can be assimilated directly into the blood, perhaps within half an hour, and consequently quickly sustain the body with new energy.

It may well be that the idea of "direct fuel injection," which is making such headway in the improvement of energy output of engines, can be usefully applied to the human mechanism destined for high-altitude flying.

Broadly speaking, there are, from the point of view of human resistance, three regions of altitude; the first up to some 9,000ft., where no special help is required; the second from that height to approximately 18,000ft., where oxygen (whether with or without carbon dioxide—CO_2—is still not unanimously agreed) must be supplied. Finally, the third zone, about 30,000ft., where a pressure cabin is necessary. For above this altitude an oxygen mask may supply enough oxygen, but the rarified atmosphere does not exert sufficient pressure to force the oxygen into the blood-stream.

Oxygen Equipment

Information published by Boothby, Lovelace and Benson on investigations conducted in the American Mayo Laboratory of Aviation Medicine reveals further that, while oxygen is frequently efficiently used as low as 12,000ft. to counteract fatigue, if it is cut off at 25,000ft. unconsciousness sets in in three minutes, and above 29,000ft. in one minute, with a complete coma soon after. There is, therefore, no doubt that with modern fast-climbing aircraft the oxygen mask becomes a most necessary part of equipment, not only for specific altitude performance but for those eventualities in which the pilot may have to seek higher altitudes.

The constant improvements in the design of the oxygen mask will make its use less cumbersome, and give more comfort and freedom of movement. An example of an improved type is shown on p. 195. This is an Italian version specially designed for extra comfort in wear. This nose mask does not obstruct the mouth, and makes talking, yawning and eating quite easy. In the case of nausea—it is said—there is also no danger of soiling the mask.

The flying personnel is rightly given more and more utility equipment which provides for their protection and comfort. The mobile oxygen units allow the crew to move about freely; the automatic oxygen flow regulator increases or reduces the oxygen supply according to the prevailing atmospheric conditions without being watched and operated by the crew. For flights of long duration at high altitude the pressure cabin provides for the protection of human life.

Scientific opinion may yet be in disagreement as to the advantages or drawbacks of various types of equipment. While many problems have been solved, others remain to be tackled. The additional weight of the pressure cabin and the resulting detraction from the performance of the machine, the vulnerability of such a cabin to gun-fire, the heat compensation—these are but a few of the problems which are involved in the technical research of high-altitude flying.

Yet research study, experience, and the practical application of accumulated knowledge of the human aspect of the problem, have made possible the steady advance of human flight into altitudes which only a short period ago were considered the domain of record-breaking adventure.

U.S. May Join Training Plan

SOME new measure of co-operation in air training between the British Empire and the United States is regarded in Canada as a possibility now that the United States is faced with the problem of expanding its air arm.

Negotiations between the four Empire countries participating in the British Commonwealth Air Training Plan for an extension of the agreement on which the plan operates are understood to be in abeyance at the moment.

If co-operation with the United States is decided on, it is likely representatives of that country will attend the negotiations when they are started again, according to information from Ottawa.

Preliminary discussions concerning extension of the agreement were started in London some time ago, according to a statement by Hon. C. G. Power, Canadian Air Minister. The present position is understood to be that the Canadian Government had proposed a conference of representatives of the four countries concerned, Canada, the United Kingdom, Australia and New Zealand, to pursue the negotiations.

It is expected that the conference will be held in Ottawa.

Correspondence

The Editor does not hold himself responsible for the views expressed by correspondents. The names and addresses of the writers, not necessarily for publication, must in all cases accompany letters.

LUNAR SPACE VESSEL

Exhaust Velocity from Solid Fuel

WITH regard to the statement in Mr. R. A. Smith's article in *Flight* of February 12th, that a fuel with an "exhaust velocity" of 3.9 km./sec. would make space travel practicable, it is a fact that a number of chemical combinations contain more energy than is represented by this figure. The theoretical value for the oxy-hydrogen mixture is over 5 km./sec. and certain solid mixtures give values of up to 6 km./sec.

A great deal of research will have to be done before suitable fuels *and* motors are evolved, but 3.9 km./sec. is by no means an unreasonable figure.

ARTHUR C. CLARKE,
Hon. Treasurer, British Interplanetary Society.

Not Just a Wellsian Fantasy

I WOULD like to congratulate *Flight* on its enterprise in publishing Mr. R. A. Smith's article, "Lunar Space Vessel," in its February 12th issue. While no one could accuse your journal of undue conservatism, it must have taken some editorial courage to publish a paper on such a subject as astronautics, which many engineers, even in the aeronautical field, will no doubt regard as Wellsian fantasy. That this should be so serves only to indicate their failure to learn the lessons of the rapid progress of aviation since the Wright Bros., only 38 years ago, flew the first airplane at an air speed of 35 m.p.h. for a duration of less that a minute.

I am one of the younger generation of aeronautical engineers who believes that flight beyond the atmosphere is to-day a less fantastic proposition than flight within it was in the days of Stringfellow. Admittedly, much work separated the proposals of this early pioneer from the Wrights' final achievement, and similarly, as Mr. Smith points out, much remains to be done before we can fly in outer space.

However, even in the intervening development period, many interesting and useful aeronautical applications of the rocket can be found. One, which the Germans have not been slow to exploit, is the assistance at take-off of heavily loaded aircraft. Another is the design and construction of very high altitude sounding rockets to improve our knowledge of the upper atmosphere.

For a description of the possibilities of this latter development, readers of *Flight* are referred to two very interesting articles in the American *Journal of the Aeronautical Sciences* for March and December of 1938. A. V. CLEAVER.

JETS AND SPACE VESSELS

A Reader Expresses Appreciation

I WOULD like to thank you and Mr. Geoffrey Smith for the final article on Jet Propulsion (*Flight*, Feb. 19th), bringing this series right up to date. I have been a regular reader for a long time, but I have never been more interested in any of your previous articles.

I would like to mention a little known point which interested me. I could not see how an internal combustion turbine could compete with a reciprocating engine, in view of the vastly higher temperatures permissible instantaneously (2,500° C.) in the reciprocating type. Then I found that the thermal efficiencies of both the constant volume and constant pressure cycles can be written as

$\frac{T_1 - T_0}{T_1}$ where T_0 = Inlet temperature,
T_1 = Temperature after compression, but before combustion.

This formula makes it clear that if the same compression temperature can be used, the maximum temperature being kept down to workable limits by using vastly larger quantities of air (weaker mixtures), the thermal efficiency for the two systems will be the same. I might add that for the conventional engine T_1 is normally just under 450° C

I would like to thank you also for the article on the Spaceship in your Feb. 12th number. Nothing has so successfully transported me away from the gloomy events of war as this charming little theoretical study; so much nicer and pleasanter than a bridge problem or a cross-word.

In his second formula, Mr. R. A. Smith has used the Theorem of Momentum with no reference to gravitational effects. In case "Mr. Gravity" feels himself slighted, and to keep the problem theoretically perfect, I would like to add this term.

Using Mr. Smith's symbols, the formula becomes:—

$$V_t = -v \log_e (M_o/M_t) - \int_0^t \frac{g\, r^2\, dt}{x^2}$$

The integral can readily be evaluated for constant acceleration, but is an awkward and untidy function.

I would like to ask Mr. Smith why he selects an acceleration which will get him up to supersonic speeds before leaving the atmosphere. I believe that, even neglecting atmospheric drag, a slower acceleration would be more economic in rocket powder. O. LAWRENCE, M.A.

THE TANK BUSTER

Energy and Momentum

YOUR correspondent, R. C. Abel, in his letter "The Tank Buster," says that a six-pound shell fired at 4,000ft. per sec. has twice the "energy" of a 12-pound shell fired at 2,000ft. per sec. He goes on to say that this energy equals force × shift.

It is difficult to understand what is meant by this term, for if he means momentum, the energy or momentum possessed by both projectiles on leaving the barrel of the gun, will in both cases be exactly the same. For momentum equals mass × velocity. Also if the energies possessed by the two shells are different, how can the recoil be the same for both, for action and reaction are *equal* and opposite.

He then says that this energy, force × shift, is the factor which governs the rise against gravitation or the piercing of armour. The ability of a shell to rise against gravitation or to pierce armour depends, apart from its shape, almost entirely upon the momentum it possesses.

This seems to indicate that your correspondent means momentum when he refers to force × shift, if this is so, how can the discrepancy between the energies possessed by the two shells be accounted for? E. D. GRAHAM.

SYNTHETIC RUBBER

Advantages Over Natural Product

I WAS interested to note on page 151 of your issue of February 19th a photograph of a Junkers JU 88, captured in Libya, the caption to which drew attention to "the fabric covers over the wheels to protect the synthetic rubber from the African sun."

Some recent examples of other "superiority delusions" urge me to correct any impression that may have been given to some readers that synthetic rubber is inferior in the above respect to the natural rubber so far used for the tyres of all R.A.F. aircraft. I would point out that synthetic rubber is, in fact, very much superior to the natural product in its resistance to deterioration or ageing through exposure to direct sunlight, oxygen of the atmosphere, ozone, etc. Actually, it is a frequent British and American practice, in fields such as electrical insulation, to apply a jacket of synthetic rubber over natural rubber in order to protect the latter from the effects of light, air, ozone, oils and other deteriorating influences.

Unlike natural rubber, most synthetic rubbers, moreover, have excellent oil resistance; thus, synthetic rubber glands and seals are invariably used in the hydraulic systems of our aircraft which use mineral oil as the hydraulic medium.

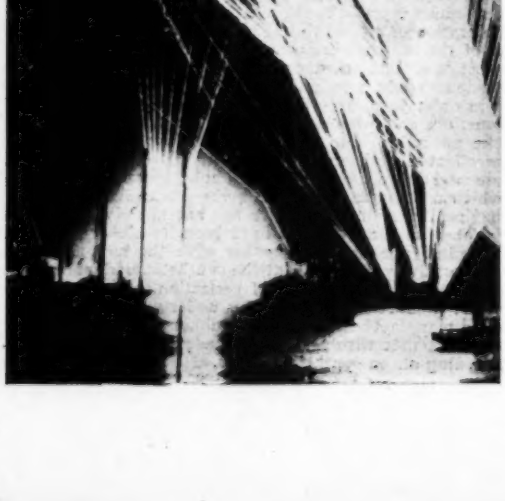
I imagine the main reasons we are not already using synthetic rubber for aircraft tyres have been its higher cost and, so far, limited availability, together with the fact that it is only comparatively recently that the synthetic product has been developed to its present degree of perfection. However, now that a vast production programme is under way in the United States for manufacturing synthetic rubber from petroleum, I would predict that within two or three years the R.A.F. will also be taking off on synthetic rubber. A. R. OGSTON.

War in the Air

Handley Page Halifaxes off in formation on an operational flight.

The Fighting for Java : More Raids on Australia : General MacArthur's Air Stroke : German Parachute Troops in Russia

THE gallant attempt of the United Nations' sea and air forces to fight off the invading Japanese forces before they reached Java cost them two Dutch cruisers, which were torpedoed by submarines as they returned from the fight. This is a heavy loss to a small naval force. The Japanese claim much greater successes, including the sinking of H.M.S. *Exeter*, of River Plate fame, but their claims are usually so exaggerated that one pays no attention to them until one hears the true facts from some reliable source, and the British Admiralty often declines to be drawn into giving information in response to Axis claims.



TRIPOLITANIAN SERENADE : The ground defences of Tripoli go into action against our attacking night bombers.

It is certain that the Japanese also lost heavily in that action, but how heavily is not known for certain. It is certain, however, that Blenheims and Fortresses got at the transports and bombed them heavily, with considerable destruction of the troops on board. Very probably the task of the Allied bombers was made easier by the damage already inflicted on the Japanese escorting warships. For the moment, the enemy can afford losses of ships and men more easily than the Allies can, but that state of affairs is only temporary. America and Britain have an infinitely greater power of replacement, though the process must take time. The Japanese are staking their all on a single throw of the dice, which for the moment are loaded in their favour.

So, despite the strenuous and gallant efforts of the United Nations, the Japanese succeeded in landing large forces on Java, and the defenders have been heavily out-numbered. Apart from general principles, it has been found that Japanese soldiers are much less formidable in defence than they are in attack, and so the defenders of Java, like those in Burma, have been attacking continuously. But the enemy succeeded in getting possession of airfields in Java, and gradually established air superiority. The support given by Hurricanes and Dutch fighters was gradually reduced, and then the defenders began to suffer from the enemy dive-bombers. The airmen who found themselves without

POLE SQUATTER: P/O Lynch of the Eagle Squadron inspecting his Spitfire after hitting a French telegraph pole. Some six inches of the pole remained stuck in the wing.

any aircraft to keep in order joined the ground forces and fought as infantrymen.

The following account of the work of the Blenheims has reached the Air Ministry: Some of the aircraft made as many as five sorties, returning to their bases just long enough to take on fresh bomb loads and to reammunition their guns. It was not necessary for them to refuel owing to the nearness of the Japanese ships. Several crews made three journeys of attack before handing over their aircraft to relief crews. The bombing attacks began at dusk. The enemy transports were between 50 and 60 miles offshore, with protecting naval vessels. The high moon gave plenty of light.

A Flight Lieutenant, describing the attack, said: "We looked around for something worthwhile at which we could let go our bombs, and found a large ship. We set our course, and saw bombs hit the ship just forward of the bridge. Then the whole 'works' went up in an explosion. It was the most glorious explosion I ever saw. On my next trip I let go my bombs before I noticed that the ship at which I was aiming was already on her side with lifeboats standing by. Somebody else had got in first at that particular ship. Soon after I came across a dozen transports lined up, but, unfortunately, had no more bombs left."

Australians and Americans

THIS same group of transports was attacked by another Blenheim flown by an Australian sergeant from Melbourne. The sergeant pilot dropped his bombs on the bows of a large enemy transport, and was then himself attacked by six enemy night fighters. He flew straight out to sea until he had shaken off the enemy; then turned and eventually landed safely in a paddy field, out of fuel.

The Royal Australian Air Force has been taking most energetic action against the Japanese at Rabaul, bombing them with admirable persistance. The Japanese have responded by more raids on Australian soil. Not only Darwin, but also Wyndham and Broome have been bombed, but the two latter towns suffered no damage and no casualties. Broome, by the way, is almost an Asiatic town, numbers of Japanese pearl-divers having settled there. No doubt they acted as a Fifth Column, but they may not have enjoyed the air raid by their own countrymen.

A more cheerful action has taken place off the Gilbert Islands, where an American naval force, consisting of an aircraft carrier, cruisers and destroyers, was twice attacked by Japanese heavy bombers. No damage was done to the ships, and 16 of the enemy raiders were shot down.

In Luzon, Philippines, the heroic General MacArthur continues to strike at the superior forces of the Japanese. One did not know that he had much of an air force at his command, but the other day his aircraft made a sudden and unexpected raid on Japanese shipping in Subic Bay. No Japanese aircraft interfered with them, and they sank three sizeable enemy ships and damaged others, without loss to themselves. It is reported that thousands of Japanese soldiers were drowned. It was one of the most dramatic incidents of the war in the Pacific up to date.

General Wavell has had his command changed once again, and has gone back to India, which now, from a military point of view, includes Burma. His brief tenure of supreme command of all forces in the South-west Pacific will, however, go down to history as a precedent for further combinations of arms under one commander.

Incidentally, it has now been reported that the Indian Air Force has taken part, not only in reconnaissance flights, but in bombing raids on the Japanese. That force is beginning to grow up. It may be recalled that at least three Indians, one Sikh and two Bengalis, were fighter pilots in the R.F.C. in the last war. The R.A.F. and A.V.G. continue to hold superiority on this front.

There is no disposition on the part of Allied air crews to think lightly of the Japanese. The general verdict is that they shoot well and that their

FRISKING FRITZ: A German airman prisoner captured during the Bruneval raid by paratroops being searched on the way back to England.

ENEMY AIR LOSSES TO MARCH 7th.

	Over G.B.	Over Continent	Middle East	Far East
March 1	0	0	0	0
" 2	0	0	2	5
" 3	0	1	1	6
" 4	1	0	3	5
" 5	0	0	1	1
" 6	0	0	2	0
" 7	1	0	0	0
	2	1	9	17

Totals: North, 5,656; Middle East, over 3,520; Far East (unofficial), 300.

WAR IN THE AIR

bravery is fanatical. But they must have been sitting back and thinking seriously about their losses in their most recent offensives. Their Army 97s simply crumple up before the fiercely driven home attacks and counter-attacks of the Allies. The American Volunteer Group, who have been exacting such a terrible toll of the Japanese, have won the whole-hearted admiration of the R.A.F. In some places, in addition to fighting, the R.A.F. have performed other services, notably the ferrying of civilians, including many women and children, out of the danger zone.

Severe fighting continues all along the front in Russia, and one very interesting fact about the German situation is that they have been using parachute troops as ordinary infantry to repel Russian attacks. That certainly seems wasteful, and shows the German need to send up reinforcements at all costs. It has now been announced that the R.A.F. Fighter Wing has returned from Murmansk, leaving their Hurricanes for Russian pilots to fly. Sir Archibald Sinclair stated in his Air Estimates speech that the Russians now hold air superiority over the Germans along the whole of that front.

The succession of raids on Malta has been carried on, with some deplorable loss of civilian life and damage to property. But recently a more cheering report has come from there to the effect that the losses which the defences have inflicted on the enemy are beginning to tell, and that the Germans are feeling the depletion of their bomber squadrons. In consequence they have begun to use fighter-bombers, as they did in the closing stages of the Battle of Britain. These machines set the sirens going, but they do not do so much damage as the real bombers can do.

R.A.F. Over France

THE R.A.F. raid on the Renault factory on the outskirts of Paris was explained by the Air Minister in his Estimates speech as marking, not a change in policy, but a change in weather. The factory had been turning out tanks for the Germans, and other equipment, too, and we obviously could not permit that to go on within easy reach of our bombers. From the point of view of destruction, the raid was extremely successful, and will have an appreciable effect on the equipment of German divisions to be used against Russia. It was unfortunate that French workmen lost their lives in the raid, but the outburst of Marshal Petain against "criminal aggression" which brought "innocent civilians to their deaths" was quite illogical. We cannot regard as innocent anybody who makes arms to be used against our Russian ally.

BRITISH AIR LOSSES TO MARCH 7th.

	Over G.B. A'crft.	Over Continent Bombers.	Middle East A'crft.	Far East A'crft.
March 1	0	0	0	0
" 2	0	0	5	0
" 3	0	2	0	3
" 4	0	0	0	2
" 5	0	0	3	0
" 6	0	0	0	0
" 7	0	1	0	0
	0	3	8	5

Totals: North, 3,288; Middle East, about 999; Far East (unofficial) about 34.

The Renault raid was followed by an afternoon attack on other factories near Paris and elsewhere in France. A night attack by Bomber Command on the enemy naval base at St. Nazaire was also good work. We have been regularly bombing French ports used by the enemy and power stations in northern France for nearly two years, but it was only the attack on the outskirts of Paris which evoked an outburst from Marshal Petain. By the same token, our pilots on daylight raids have often seen French peasants and fishermen waving good luck to them as they flew overhead. The soul of the French people is still sound and logical, whatever the titular head of France may say.

The weather throughout February was very bad for air operations, but Bomber Command was at work on 16 nights, while the R.A.F. as a whole carried out offensive operations on 17 days as well. The enemy only made small attacks on Great Britain on nine nights and engaged in even smaller activities by day on ten occasions, with very meagre results.

HIGH SPEED DEMOLITION: The terrific striking power of Bomber Command is exemplified in this photograph of the wrecked Renault factory at Billancourt. The raid lasted slightly less than two hours.

"Flight" photograph.

A striking cloudscape with a Westland Whirlwind silhouetted against an intense blue sky.

Royal Air Force and Fleet Air Arm News and Announcements

Awards

Channel Battle

V.C. Awarded

THE KING has been graciously pleased to approve the grant of the Victoria Cross, for valour and resolution in action against the enemy, to:—

The late Lt.-Cdr. (A.) E. ESMONDE, D.S.O., R.N.—On the morning of Thursday, February 12th, 1942, Lt.-Cdr. Esmonde, in command of a squadron of the Fleet Air Arm, was told that the German battle-cruisers *Scharnhorst* and *Gneisenau* and the cruiser *Prinz Eugen*, strongly escorted by some thirty surface craft, were entering the Straits of Dover, and that his squadron must attack before they reached the sandbanks north-east of Calais.

Lt.-Cdr. Esmonde knew well that his enterprise was desperate. Soon after noon he and his squadron of six Swordfish set course for the enemy, and after ten minutes' flight were attacked by a strong force of enemy fighters. Touch was lost with his fighter escort; and in the action which followed all his aircraft were damaged. He flew on, cool and resolute, serenely challenging hopeless odds, to encounter the deadly fire of the battle-cruisers and their escort, which shattered the port wing of his aircraft.

Undismayed, he led his squadron on, straight through this inferno of fire, in steady flight towards their target. Almost at once he was shot down; but his squadron went on to launch a gallant attack, in which at least one torpedo is believed to have struck the German battle-cruisers, and from which not one of the six aircraft returned. His high courage and splendid resolution will live in the traditions of the Royal Navy, and remain for many generations a fine and stirring memory.

DISTINGUISHED SERVICE ORDER.

His Majesty has also been graciously pleased to give orders for the following appointments to the Distinguished Service Order, and to approve the following awards:—

TO BE COMPANIONS OF THE DISTINGUISHED SERVICE ORDER.

Temp. Act. Sub-Lt. (A.) B. W. ROSE, R.N.V.R., who was pilot of one of the Swordfish aircraft sent to attack the German battle-cruisers. His aircraft was hit early in the action; but though in great pain from a wound in his back, he held on his course. Another hit burst his petrol tank, and his engine began to fail, but with unshaken resolve he flew on, and came within 2,000 yards of the enemy before he dropped his torpedo, which was last seen running well towards the target. Then he flew back across the fire of the enemy escort, and his aircraft, now on fire, came down into the sea just beyond.

Temp. Act. Sub-Lt. (A.) E. F. LEE, R.N.V.R., who was Observer to Sub-Lt. Rose.—Before the Swordfish had reached the enemy escort vessels

Flt. Sgt. W. A. Cox leaving Buckingham Palace with his wife after being invested with the D.F.M.

their air gunner was killed. Sub-Lt. Lee stood up in the cockpit and directed the pilot so that he could evade the attacking enemy fighters. He went on doing this until his aircraft came down in flames. Then, although under fierce fire from the enemy, he got his wounded pilot, who was very much heavier than he, into his dinghy, and returned to the aircraft, but found it sinking. For an hour and a half he stayed in the flooded dinghy, tending and encouraging his wounded pilot, and never losing heart, until both were rescued.

Temp. Act. Sub-Lt. (A.) C. M. KINGSMILL, R.N.V.R., and Sub-Lt. (A.) R. McC. SAMPLES, R.N.V.R., who were pilot and observer of a Swordfish that was badly hit early in the action by cannon shells from an enemy fighter. Both were wounded, but with part of the aircraft shot away, and the engine and upper wing in flames, they flew on undaunted until they had taken aim and fired their torpedo. They then turned and tried to come down near some ships, but these opened fire, so they flew on until their engine stopped, and their aircraft came down into the sea. Soon afterwards they were picked up, still cheerful and dauntless, by one of H.M. vessels.

THE CONSPICUOUS GALLANTRY MEDAL.

Naval Airman 1st Cl. D. A. BUNCE, who was air gunner in the Swordfish aircraft piloted by Sub-Lt. Kingsmill.—With his machine on fire, and the engine failing, he stayed steadfast at his gun, engaging the enemy fighters which beset his aircraft. He is believed to have shot one of them down. Throughout the action his coolness was unshaken.

MENTION IN DESPATCHES (POSTHUMOUS).

Lt. (A.) J. C. THOMPSON, R.N.
Sub-Lt. (A.) R. L. PARKINSON, R.N.
Sub-Lt. (A.) C. R. WOOD, R.N.
Temp. Sub-Lt. W. BEYNON, R.N.V.R.
Temp. Sub-Lt. (A.) E. H. FULLER WRIGHT, R.N.V.R.
Temp. Act. Sub-Lt. (A.) P. BLIGH, R.N.V.R.
Ldg. Airman E. TAPPING.
Temp. Ldg. Airman W. G. SMITH.
Temp. Ldg. Airman H. T. A. WHEELER.

The last that was seen of this gallant band, who were astern of the leading flight, is that they were flying steadily towards the battle-cruisers, led by Lt. Thompson. Their aircraft shattered, undeterred by an inferno of fire, they carried out their orders, which were to attack the target. Not one came back. Theirs was the courage which is beyond praise.

Ldg. Airman A. L. JOHNSON, D.S.M., who, as air gunner to Sub-Lt. Rose, showed the same dauntless spirit. He was killed early in the action.

How the R.A.F. fighter wing lived during its stay in Russia. A scene in a dugout which served as a dispersal hut.

Lt. W. WILLIAMS, R.N., and Ldg. Airman W. J. CLINTON, who, as observer and air gunner to Lt. Cdr. Esmonde shared his fate in this gallant action, and showed the same high courage.

Fleet Air Arm

DISTINGUISHED SERVICE ORDER.

Lt. Cdr. F. H. E HOPKINS, D.S.C., R.N.—In recognition of the leading part he played in a successful air attack on an important enemy convoy on its way to Tripoli on the night of January 23-24. It was due to his unflagging devotion to duty and his determination that the convoy, although outside the safe range of the Swordfish aircraft available in the prevailing bad weather conditions, was located and later attacked. As a result of this and other attacks the heavily escorted Italian liner *Victoria* (13,098 tons) was hit with torpedoes and almost certainly sunk. To achieve this result, Lt. Cdr. Hopkins made flights lasting nearly 12 hours through bad weather, which steadily grew worse. First he led a number of Swordfish on a search for the convoy. Rain and a low ceiling of cloud made the search very difficult. By the time the convoy was sighted all but two of the aircraft had been forced to return to their base.

Although he now knew that the convoy was outside the safe operational range of his aircraft, which meant that attacking aircraft might not be able to get home again, Lt. Cdr. Hopkins was not deterred. He flew back to his base and organised a striking force of Swordfish torpedo-carrying aircraft. By this time the weather had grown still worse, but he set out again with the new formation. Again the convoy was located and the Swordfish dived to the attack. Two torpedoes were seen to hit the liner, and later aircraft reconnaissance could find no trace of this ship. It was Lt. Cdr. Hopkins' refusal to be deterred from getting at the enemy which made this success possible.

R.A.F. in Russia

DISTINGUISHED FLYING CROSS.

Wing Cdr. H. N. G. RAMSBOTTOM-ISHERWOOD, A.F.C., No. 151 Wing, R.A.F. in Russia.—This officer has displayed great leadership and set a splendid example. He contributed materially to the successes obtained by our pilots in Russia.

Sqn. Ldr. A. H. ROOK, No. 81 Squadron.—This officer led the squadron with great skill and dash during combat when it destroyed 13 enemy aircraft for the loss of only one of our own pilots. Sqn. Ldr. Rook has always fostered the fighting spirit in his fellow-pilots which, together with his leadership, was responsible for the excellent record of the squadron in Russia.

Sqn. Ldr. A. G. MILLER, No. 134 Squadron.—This officer has led his squadron with high qualities of determination and judgment. During the many escorts to Russian bomber aircraft, either led by himself or provided by his unit, not a single Russian bomber was lost.

THE KING has been graciously pleased to approve the following awards in recognition of gallantry displayed in flying operations against the enemy:—

DISTINGUISHED FLYING CROSS

F/O. A. BARR, R.A.A.F., No. 3 (R.A.A.F.) Squadron. This officer, who commenced operational flying in November, 1941, has displayed the greatest keenness and skill as a fighter pilot. In December, 1941, during a patrol over the Derna area, he shot down a Messerschmitt 110; the next day, in the same area, he destroyed a Messerschmitt 110 and a Junkers 88.

One day in January, 1942, his squadron formed part of an escort to bomber aircraft operating over El Agheila. Enemy aircraft were encountered and, in the ensuing engagement, F/O. Barr attacked two Italian fighters one of which he shot down. He then observed one of his fellow pilots, who had been shot down, waving to him from the ground, but, when preparing to make a landing in an attempt to rescue him, F/O. Barr was attacked by two Messerschmitt 109s.

Although the undercarriage of his aircraft was not fully retracted, he immediately manœuvred to engage the attackers only to find that his guns had jammed. Quickly rectifying the fault, he delivered an accurate burst of fire which caused one of the Messerschmitts to disintegrate in the air. A further two enemy aircraft joined in the combat and F/O. Barr was wounded and forced down.

While on the ground he was further wounded by the enemy's fire, but, despite this, he made his way through the enemy's lines and rejoined our own forces some three days later. He brought back much valuable information regarding the disposition of enemy tanks and defences. F/O. Barr displayed the greatest courage and tenacity throughout. He has destroyed eight enemy aircraft.

P/O. J. MOSS, No. 208 Squadron.—One day in January, 1942, this officer carried out a photographic reconnaissance of the battle area. While making his run over the area at 20,000 feet, P/O. Moss observed three enemy fighters flying to intercept him. Nevertheless, he continued his run for some eight minutes and, when the attackers prepared to engage him, he put his aircraft into a violent turn and spiralled down to 4,000 feet, which caused the windscreen and hood to become iced-up and reduced his visibility to a minimum.

When below 4,000 feet, the ice cleared and P/O. Moss observed that the enemy fighters were still in pursuit, but, adopting both skilful and disconcerting tactics, he cleverly evaded the enemy. He finally eluded his pursuers in a sand storm near a landing ground, but he was unable to land there owing to the sand storm.

Realising, however, that his petrol was becoming exhausted, he flew clear of the tents and mechanised transport and made a safe landing with the undercarriage of his aircraft retracted and without incurring any damage to his camera. He then commandeered a vehicle and returned to his squadron with his photographs. P/O. Moss displayed courage and resource in accomplishing a most valuable reconnaissance.

P/O. C. H. W. GLENN, R.A.F.V.R., and P/O. D. Q. MILLER, R.A.F.V.R., both of No. 144 Squadron.

In December, 1941, P/Os Glenn and Miller were the pilot and navigator respectively of one of a force of aircraft which was detailed to carry out a low-level daylight attack on the battle cruiser *Gneisenau* at Brest. Skilful navigation by P/O. Miller enabled the aircraft to break cloud cover over the target area, but, in the run up to attack, an extremely fierce and accurate barrage was encountered, and the aircraft was repeatedly hit by shell-fire. When nearing the objective, the starboard wing of the aircraft touched the cable of a balloon, which was obscured by the clouds, causing the aircraft to swerve violently. P/O. Glenn regained control and headed for the objective. Almost immediately a shell burst on the tail-plane, inflicting such damage that the aircraft became almost uncontrollable. In harassing conditions, P/O. Glenn succeeded in flying the aircraft back to an airdrome in this country, where a safe landing was made. Throughout, P/Os Glenn and Miller displayed rare courage, skill and tenacity. Both officers have carried out repeated attacks against the most strongly defended enemy targets.

P/O. M. A. ENSOR, R.N.Z.A.F., No. 500 Squadron. For citation see Sgt. Paige below.

DISTINGUISHED FLYING MEDAL.

Sgt. B. C. PAIGE, R.C.A.F., No. 500 Squadron.—One night in January, 1942, P/O. Ensor and Sgt. Paige were the pilot and observer respectively of an aircraft which was engaged on an operational sortie over enemy waters. A convoy of three ships was observed sailing through the ice

Air Commandant K. J. Trefusis-Forbes, Director of the W.A.A.F., inspecting senior non-commissioned officers at a training establishment in the West of England.

AVIATION

flees. P/O. Ensor attacked the leading ship from mast height and scored direct hits with some of his bombs.

Whilst taking violent evasive action, at an extremely low altitude, the aircraft struck a rock which disabled the starboard engine, rendered all instruments and the turret unserviceable, and extinguished all the lights. Thus handicapped, P/O. Ensor skilfully regained height in a heavy snowstorm, but later, whilst flying over land and uncertain of his bearings, his aircraft was subjected to anti-aircraft fire and searchlight activity for some 30 minutes.

Eventually, the position was identified and, ably assisted by Sgt. Paige's excellent navigation, P/O. Ensor flew across the sea with only one engine of his aircraft functioning. On reaching this country he was compelled to attempt a forced landing owing to shortage of petrol and, although it was snowing heavily, assisted by Sgt. Paige, who fired Very lights in quick succession in an endeavour to illuminate his surroundings, P/O. Ensor made a safe landing without further damage to the aircraft or injury to the crew.

Throughout this officer showed great courage, skill and tenacity and was greatly assisted by the coolness and efficiency of Sgt. Paige.

GEORGE MEDAL.

THE KING has been graciously pleased to approve the award of the George Medal to the undermentioned airman:—

Cpl. E. G. DURANT.

In November, 1941, an aircraft caught fire, and one of its bombs exploded. Cpl. Durant led the fire tender party to the scene after the first explosion, knowing full well that further explosions could be expected from the remaining bombs. On reaching the blazing aircraft, Cpl. Durant observed an injured airman lying near the wreckage and, assisted by another airman, promptly dragged him clear.

Whilst carrying the injured airman to the comparative safety of the fire tender, they were twice hurled to the ground by the force of the explosion from two further bombs. Leaving the injured airman to the care of the medical orderly in charge of the ambulance, Cpl. Durant led a party to the other side of the aircraft, whence he had heard a cry for help, and helped to extricate another casualty from the fire.

Throughout, Cpl. Durant displayed fine leadership and complete disregard of his own safety, and with the assistance of another airman was undoubtedly responsible for saving the life of one of the occupants of the blazing aircraft. Unfortunately, the second occupant, who was rescued subsequently, died of his injuries.

Roll of Honour

Casualty Communique No. 115.

THE Air Ministry regret to announce the following casualties on various dates. The next-of-kin have been informed. Casualties reported "in Action," are due to flying operations against the enemy; "on active service" includes ground casualties due to enemy action, non-operational flying casualties, fatal accidents and natural deaths.

Guests of Vichy. A group of R.A.F. personnel interned in the *Camp des Internees Britanniques* at Laghouat, Algeria.

Royal Air Force

KILLED IN ACTION.—P/O. K. D. Adams; Sgt. H. Berry; Sgt. A. R. Breakspear; Sgt. A. H. Coupe; Sgt P. A. Fry; Sgt. R. J. C. Garrett; Sgt. H. E. Godson; Act. Flt. Lt. H. Goolden; Sgt. N. R. Graystone; Sgt. G. D. Hart; Sgt. E. Henowy; Sgt. S. Irvine; Sgt. G. T. Kettle; Sgt. T. P. McBride; Sgt T. Macorry; Sgt. S. A. Peters; Sgt. A. O. Pitcher; Sgt. L. A. Rowe; Sgt. W. T. Tromans; Sgt. A. G. Walker.

PREVIOUSLY REPORTED MISSING, BELIEVED KILLED IN ACTION, NOW PRESUMED KILLED IN ACTION.—Sgt. G. A. Avory; Sgt. H. H. M. Barton; Flt. Sgt. B. W. F. Bates; Sgt. A. J. Box, D.F.M.; Sgt. J. A. Brooks; Sgt. K. F. Capper; Sgt. R. L. Cole; Sgt. D. N. N. De Brath; Sgt. H. M. Elder; Sgt. J. N. Fergus; Sgt. H. A. French; P/O. J. B. Gower; Sgt. G. D. H. Griffiths; Sgt. G. J. P. Hartlett; Sgt. D. C. Hayward; Sgt. J. F. Hollingworth; Sgt. R. K. Hutt; Sgt. A. Jepson; Sgt. E. S. Jones; P/O. G. M. Kennedy; Sgt. N. J. Lake; P/O. R. A. Lomax; Sgt. C. G. J. McIvor; Sgt D. J. Macpherson; Sgt. H. E. Meadows; Sgt. G. E. Morgan; Sgt. I. B. Outram; Sgt. P. T. Perrins; Sgt. P. T. Relf; Sgt. G. W. Richardson; F/O. J. E. Speak; Sgt. G. H. Spickett; Sgt. K. J. Whadcoat; Sgt. A. D. Wills.

PREVIOUSLY REPORTED MISSING, NOW PRESUMED KILLED IN ACTION.—P/O. A. E. C. Adkins; Sgt. F. W. Alleway; Sgt. C. C. G. Ashcroft; Sgt. L. E. Badland; Flt. Sgt. R. S. Bagnall; Sgt. E. Bainbridge; Sgt W. J. Baird; P/O. M. R. F. Baker; Flt. Lt. K. R. Ball; Sgt. D. N. Banks; Sgt. G. G. Bensley; Sgt. M. V. Berry; Sgt. J. H. Bevans; Flt. Sgt. N. E. Bowering; Sgt. K. W. Bramble; Sgt. R. Brearley; Sgt. H. Breisford; Sgt. T. A. Bridewell; Sgt. C. H. Chandler; Sgt. J. Christie; P/O. H. M. Clark; Sgt. J. A. D. Clark; Sgt. P. B. N. Cleburne; Sgt. N. W. Cook; Sgt. D. Crosbie; Sgt. F. Dacy; Flt. Sgt. F. H. Dean; Sgt. C. Deges; P/O. D. G. Dickie; Sgt. F. C. Dodd; Sgt. A. Eaves; Wing Cdr. J. L. H. Fletcher; Sgt. M. Ford; Sgt. J. V. Gill; P/O. R. G. Gilmore; Sgt. A. L. Glaves; Flt. Sgt. F. Grail; Sgt. D. M. Greey; Sgt. R. G. G. Griffin Sgt. A. E. Guesford; Sgt. E. R. Hall; Flt. Sgt. J. H. Harris; Sgt. A. R. J. Harrison; Sgt. D. H. Harrison; F/O. M. J. C. Harwood, D.F.C.; Sgt. R. K. Hayes; Sgt. W. P. Herman; Sgt. E. P. Hill; Sgt. F. W. Hill; Sgt. J. Hughes; Sgt. H. Hutchinson; Sgt. D. C. Hyslop; Sgt. H. B. S. Johnston; Sgt. R. D. Jury; Sgt. H. Kay; Sgt. G. A. Kaye; Sgt. F. S. B. Knox; Sgt. F. W. H. Lapsley; Flt. Sgt. N. Lusher; Sgt. P. J. McLean; Sgt. A. J. Manning; Flt. Sgt. W. R. Mathias; Flt. Lt. I. A. Mead; Sgt. W. J. Megran; Sgt. N. Moores; Sgt. J. Moules; Sgt. A. T. Niven; Sgt. H. Nykerk; Flt. Sgt. W. A. Oastler; Sgt. G. Pattison, D.F.M.; P/O. C. J. Pearson; Sgt. A. H. Peck; Sgt. R. Plume; Sgt. T. C. Quinlan; Sgt. C. C. Reidmuller; Sgt. I. L. T. Reis; Sgt. W. F. Richards; Sgt. R. Richardson; Sgt. T. K. Riley; Sgt. L. P. C. Rolfe; P/O. G. C. Rolland; Sgt. A. W. Rose; Sgt. C. F. Shearn; Sgt. A. Smith; Sgt. G. C. Smith; Sgt. J. Stead; P/O A. F. Struthers; Sgt. H. Thompson; Sgt. R. T. Timms; Sgt. H. G. Tonks; Sgt. A. L. Walker; Sgt. W. H. Walker; Sgt. D. J. Wheatley; Sgt. D. A. Whiting; P/O. G. G. Whitting; Sgt. S. W. Winter; Sgt. S. Wintersgill; Sgt. J. C. Woods; Sgt. J. G. Woolley; P/O. W. H. Zillessen.

DIED OF WOUNDS OR INJURIES RECEIVED IN ACTION.—Sgt. E. Kent; Sgt. R. St. C. Neale.

MISSING, BELIEVED KILLED IN ACTION.—Sgt. W. R. Cheesman; Sgt. J. Harrop; Sgt. T. N. Pugh.

MISSING.—Act. Sqn. Ldr. M. E. Abbott, D.F.C.; Sgt. R. Brown; Sgt. P. B. Chapple; P/O. B. P. Daniel; Sgt R. G. Eves; Sgt. M. D. Gould; Sgt. A. J. Griffiths; Sgt. I. T. James; Sgt. A. T. R. Renshaw; P/O. J. B. Scard; Sgt. J. A. Sellars.

MISSING, BELIEVED KILLED ON ACTIVE SERVICE.—A/C.2 S. Binderman; A/C.2 P. A. Boyce; A/C.2 D. H. Emmett; L.A/C. W. G. Hall; A/C.2 T. Holmes; L.A/C. H. Martin; L.A/C. W. J. Morgan; A/C.1 L. A. Parkins; A/C.1 N. W. Rees; L.A/C. S. Shalloe; A/C.1 D. R. Timms; A/C.1 C. Trask.

KILLED ON ACTIVE SERVICE.—Sgt. J. H. Arch; Sgt. J. R. V. Bones; Sgt. J. Charnock; L.A/C. E. S. Headington; L.A/C. J. A. M. Harkness; P/O. A. Petty; L.A/C. A. S. White.

PREVIOUSLY REPORTED MISSING, NOW PRESUMED KILLED ON ACTIVE SERVICE.—P/O. A. Bridson, D.F.C.

WOUNDED OR INJURED ON ACTIVE SERVICE.—P/O. H. R. Bartlett; L.A/C. A. Boniface; L.A/C. F. G. Gay; L.A/C. R. G. Graves; L.A/C. K. C. Nash; L.A/C. J. M. M. Waite; Cpl. E. H. J. White.

DIED OF WOUNDS OR INJURIES RECEIVED ON ACTIVE SERVICE.—Sqn. Ldr. G. R. Fielder; Sgt. G. Rees.

DIED ON ACTIVE SERVICE.—A/C.2 W. G. Adams; Flt. Lt. R. G. Ashton; A/C.2 D. S. Baraclough; A/C.1 W. H. Bell; Flt. Sgt. J. E. Campbell; L.A/C. W. E. Cooper; A/C.1 A. Cruddas; Sgt. A. S. Ditch; L.A/C. J. Elliott; A/C.1 R. Ellis; P/O. W. R. Ellis; L.A/C. S. W. Friend; A/C.2 D. J. Gale; L.A/C. L. Gould; A/C.1 T. Heath; L.A/C. J. Howlett; A/C.2 W. E. C. Jones; A/C.2 H. R. Kenny; L.A/C. W. W. Mackenzie; A/C.1 W. E.

The first Greek fighter squadron of the R.A.F. which is now on operations in the Middle East. It is equipped with Hurricanes.

SERVICE AVIATION

Mann; Cpl. R. J. Payne; L.A/C. W. C. L. Pink; A/C.2 J. G. Raper; L.A/C. J. Render; A/C.2 A. S. Reid; A/C.1 G. Shorrock; L.A/C. G. D. Thomas; A/C.2 E. F. Thompson; A/C.2 S. A. H. Thurlow; L.A/C. E. H. Tureczec; L.A/C. H. H. Vickers; P/O. B. R. S. Williams

PREVIOUSLY REPORTED MISSING, NOW REPORTED PRISONER OF WAR.—Act. Sgt. J. E. Andrew; F/O. A. A. Salter.

Women's Auxiliary Air Force

DIED ON ACTIVE SERVICE.—A/CW.2 E. M. Pearson.

Royal Australian Air Force

KILLED IN ACTION.—Sgt. A. D. Campbell; Sgt. H. G. Fraser; Sgt. R. G. Heron; Sgt. W. C. Williams.

MISSING.—P/O. W. J. Carroll.

Royal Canadian Air Force

KILLED IN ACTION.—Sgt. R. F. Campbell; Sgt. G. J. Peck; P/O. L. G. Schell.

WOUNDED OR INJURED IN ACTION.—Sgt. J. D. McKnight.

MISSING, BELIEVED KILLED IN ACTION.—P/O. T. G. Cottier; P/O. C. H. Lomas; Sgt. L. C. Powell.

MISSING.—P/O. H. W. Clarke; Sgt. A. L. Lewis; Sgt. H. T. McGrath.

KILLED ON ACTIVE SERVICE.—P/O. D. M. Burgess.

WOUNDED OR INJURED ON ACTIVE SERVICE.—Sgt. L. Burtnick.

DIED ON ACTIVE SERVICE.—Sgt. A. C. Darrell.

PREVIOUSLY REPORTED MISSING, NOW REPORTED PRISONER OF WAR.—Sgt. J. N. Kirk; Sgt. L. G. Spilsbury.

Royal New Zealand Air Force

KILLED IN ACTION.—Sgt. J. A. Fleming.

PREVIOUSLY REPORTED MISSING, BELIEVED KILLED IN ACTION, NOW PRESUMED KILLED IN ACTION.—Sgt. R. J. Bullen; Sgt. B. A. Clark.

PREVIOUSLY REPORTED MISSING, NOW PRESUMED KILLED IN ACTION.—Sgt. R. L. Brewer; P/O. W. T. Everist.

DIED ON ACTIVE SERVICE.—Sgt. F. H. Creed.

South African Air Force

PREVIOUSLY REPORTED MISSING, NOW REPORTED PRISONER OF WAR.—Sgt. P. A. Bleth; Sgt. G. N. Jonas; Lt. D. L. Lamont; 2/Lt. J. H. Meyer; Capt. G. W. Parsons; 2/Lt. Reynepe.

Casualty Communique No. 116

Royal Air Force

KILLED IN ACTION.—Sgt. T. Brunyee; Sgt. J. E. Duval; Sgt. S. G. Hagell; P/O. W. Hollingsworth; Sgt. H. L. Morgan; Sgt. C. F. A. Romain.

PREVIOUSLY REPORTED MISSING, BELIEVED KILLED IN ACTION, NOW PRESUMED KILLED IN ACTION.—Sgt. A. T. Copley; P/O. J. R. L. Dunn; Sgt. A. Gregory; Sgt. F. L. T. Ireson; P/O. J. R. A. Jones; Sgt. E. H. Lager; Sgt. E. Marsden; Sgt. S. R. Mayor; Sgt. J. N. R. Tate; Sgt. C. A. F. Thomas; F/O. T. Wardhaugh; Flt. Sgt. D. W. Wyatt.

PREVIOUSLY REPORTED MISSING, NOW PRESUMED KILLED IN ACTION.—Sgt. R. W. Adamson; Flt. Sgt. M. B. Appleby; P/O. J. Bailie; Sgt. G. K. Bass; Sgt. A. R. Batch; Sgt. G. Benton; Sgt. C. S. Beresford; Sgt. A. A. Bunker; Sgt. J. Butler; Flt. Sgt. N. S. Cardell; Sgt. W. J. Clarke; Sgt. J. Clayton; Sgt. P. Cowen; Sgt. P. J. Davey; Sgt. O. J. Dee; Sgt. S. P. Donoghue; P/O. J. Drewson; Sgt. A. W. Earp; Sgt. H. T. Ellis; Sgt. J. T. Evans; P/O. J. O. Fenton; Sgt. W. C. Fergusson; Sgt. V. Flynne; P/O. L. J. Francis; Sgt. F. Garbutt; Sgt. F. Gill; Sgt. P. T. Grisdale; Sgt. G. A. Hadaway; Act. F/O. H. V. T. Helmore; Sgt. R. S. Herring; Sgt. J. Hoban; Grp. Capt. E. J. L. Hope, A.F.C.; Sgt. J. St. C. Hopper; Sgt R. H. Johnson; Sgt. A. S. F. Jones; Sgt. H. Kay; Sqn. Ldr. G. A. Kitching; Sgt. S. G. Kybird; Act. Sqn. Ldr. P. W. F. Landale; Flt. Sgt. J. G. Leslie; Act. Flt. Lt. G. I. Lewis; Sgt. R. H. Lomas-Smith; Sgt. F. Lowrey; Flt. Sgt. J. T. Melvin; P/O. P. Molloy; P/O. R. D. Morley; Sgt. J. D. Norris; Act. Flt. Lt. R. F. Orchard; P/O. G. Pringle; Sgt. E. H. Reels; Sgt. W. Ross; Flt. Sgt. B. A. Rutherford; Act. Sqn. Ldr. D. A. Smith; Sgt. R. J. Somerfield; Sgt. E. J. Start; Sgt. J. Sykes; Flt. Sgt E. C. Thompson; Sgt. N. MacD. Walker; Sgt. D. G. Watkinson; Sgt. R. A. Whitley; Flt. Sgt. W. G. Williams; Flt. Sgt. T. Wood; F/O. E. J. Woods; Flt. Sgt. W. Woods.

WOUNDED OR INJURED IN ACTION.—Sgt. H. S. Grimsey; Sgt. W. McDonald; Flt. Sgt. B. J. Tyson.

MISSING, BELIEVED KILLED IN ACTION.—Sgt. J. S. Dainton, Sgt. P. F. Isaac; Sgt. F. Pearson; Flt. Lt. D. J. C. Pinckney; P/O. J. K. Russell; Sgt. A. D. E. St. C. Smithe; Sgt. A. Stockdale; Sgt. A. B. Thomas; Sgt. E. Twelves; Sgt. D. T. Williams.

MISSING.—Sgt. W. Armour; P/O. A. P. L. Barber; P/O. R. A. Baseby; Act. Sqn. Ldr. E. D. Chantler; Sgt. A. S. Chantrell; Sgt. H. S. E. Ellis; Sgt. C. R. Freeman; Sgt. P. A. Gale; Sgt. W. A. Gray; Sgt. W. M. Greenbank; Sgt. S. D. Gummery; Flt. Sgt. G. F. Gurr; Sgt. J. W. Hallam; F/O. A. M. Harvey; Sgt. W. Holland; Sgt. P. P. Hussey; Sqn. Ldr. W. B. Keddy, D.F.C.; Sgt. M. H. J. Kilburn; Sgt. R. M. Knapman; Sgt. P. D. Lowe; Flt. Lt. E. G. L. Pelling; Sgt. J. B. Riley; L.A/C. E. W. Walker.

MISSING, BELIEVED KILLED ON ACTIVE SERVICE.—P/O. J. F. Lake.

KILLED ON ACTIVE SERVICE.—Flt. Sgt. J. C. Addy, D.F.M.; Cpl. P. C. Bishop; Sgt. E. Blacklaw; P/O. D. M. Browne; L.A/C. H. E. Clothier; A/C.1 A. Condliffe; A/C.1 D. M. Foster, L.A/C. H. N. Gladman; A/C.1 L. Goldsworthy; A/C.1 H. J. Gomm; P/O. A. G. Hall; Sgt. D. B. Hancock; Flt. Sgt. W. L. Heavisides; Sgt. K. Horton; Sgt. G. Ireland; A/C.2 G. R. King; A/C.1 T. A. Kitching; Sgt. F. J. Lloyd; P/O. A. J. Low; Sqn. Ldr. J. N. Mahler, D.F.C.; P/O. W. Milne; Sgt. C. R. Morley; Cpl. T. L. Nielsen; P/O. D. F. Read; P/O. A. H. D. Reffell; L.A/C. G. W. Rowley; A/C.2 A. S. Service; F/O. R. F. Spencer-Schrader; P/O. J. D. Waddell; Sgt. R. C. Walker; Sgt. W. H. M. Watts; F/O. J. S. Wigglesworth; A/C.1 R. Wood.

PREVIOUSLY REPORTED MISSING, NOW PRESUMED KILLED ON ACTIVE SERVICE.—P/O. J. S. Curl; L.A/C. A. T. Day; L.A/C. J. McKinlay; P/O. J. Mares; Sgt. C. J. Shadbolt.

PREVIOUSLY REPORTED MISSING, BELIEVED KILLED ON ACTIVE SERVICE, NOW REPORTED KILLED ON ACTIVE SERVICE.—P/O. W. J. Henderson.

WOUNDED OR INJURED ON ACTIVE SERVICE.—Cpl. J. Cooper; Sgt. A. S. Fletcher, D.F.M.; Cpl. J. L. Ford; A/C.1 W. H. French; Act. Sqn. Ldr. L. M. Glover; Sgt. H. H. Haines; A/C.1 J. J. Hawkins; L.A/C. R. E. Jefferies; Flt. Sgt. H. Johnston, D.F.M.; A/C.1 A. M. W. Knight; L.A/C. A. Muir; A/C.2 W. T. S. Norton; Sgt. A. S. Patterson; Cpl. J. F. Roche; Cpl. C. L. G. Ryan; L.A/C. A. C. Sharp; L.A/C. G. A. Sherratt; A/C.1 J. D. Smith; L.A/C. A. E. Stuart-Cox; A/C.1 D. Whitaker.

DIED OF WOUNDS OR INJURIES RECEIVED ON ACTIVE SERVICE.—A/C.1 D. M. Clark; L.A/C. E. H. W. Grimes; F/O. P. W. Herbert; A/C.2 N. Leitch; Sgt. R. Low.

PREVIOUSLY REPORTED WOUNDED OR INJURED ON ACTIVE SERVICE, NOW REPORTED DIED OF WOUNDS OR INJURIES RECEIVED ON ACTIVE SERVICE.—A/C.2 G. J. Carpenter.

DIED ON ACTIVE SERVICE.—F/O. J. A. C. Brown; A/C.2 T. Hart; L.A/C. C. D. Henley; Cpl. S. E. Hobbs; Flt. Sgt. F. G. Mathews; Cpl. O. W. Rennie; A/C.2 E. A. Riley; A/C.1 R. Roberts; A/C.2 H. Waterson; Flt. Sgt. S. D. Wiltshire.

PREVIOUSLY REPORTED MISSING, NOW REPORTED PRISONER OF WAR.—Sgt. A. E. Glover; Sgt. G. F. Halliwell;; P/O. R. Reynolds.

Women's Auxiliary Air Force

DIED ON ACTIVE SERVICE.—A/CW.2 M. M. Neary; A/CW.1 J. E. Whitlock.

Royal Australian Air Force

KILLED IN ACTION.—Sgt. A. Hollingsworth.

PREVIOUSLY REPORTED MISSING, BELIEVED KILLED IN ACTION, NOW PRESUMED KILLED IN ACTION.—Sgt. D. L. J. Lawrence.

PREVIOUSLY REPORTED MISSING NOW PRESUMED KILLED IN ACTION.—P/O. W. D. Eccleton; P/O W. D. Willis.

PREVIOUSLY REPORTED MISSING, BELIEVED KILLED IN ACTION, NOW REPORTED KILLED IN ACTION.—Sgt. W. S. C. Atherton.

WOUNDED OR INJURED IN ACTION.—P/O. W. S. Bengtsson; Sgt. H. L. Mackay; Sgt. G. E Seaton; Sgt. J. H. P. Smith.

MISSING.—Sgt. R. C. Beckley; Sgt. B. C. Dickson; F/O. J. A. McIntosh; Sgt. R. A. Milliken; P/O. O. C. Stephens; Sgt. J. W. Wheeler.

MISSING, BELIEVED KILLED ON ACTIVE SERVICE.—P/O. D. E. Lewis.

KILLED ON ACTIVE SERVICE.—P/O. F. A. Allan; Sgt. B. Astley; Sgt G. O. Emery; Sgt. G. Hawkins; Sgt. R. W. Lindeman; Sgt. C. W. P. Ries; P/O. W. E. Ries; Flt. Sgt. R. W Taylor; Sgt. F. C. Young.

WOUNDED OR INJURED ON ACTIVE SERVICE.—Sgt. W. Dan; Sgt. J. H. Levett.

PREVIOUSLY REPORTED MISSING, NOW REPORTED PRISONER OF WAR.—Sgt. C. Cornall.

Fighter pilots of the famous No. 603 (City of Edinburgh) squadron. No longer recruited solely from "Auld Reekie," they hail from Scotland, England, America, New Zealand and Malaya.

Royal Canadian Air Force

KILLED IN ACTION.—Sgt. A. G. Buchanan; P/O. R. E Dann; Sgt. J. C. Gaudet.

PREVIOUSLY REPORTED MISSING, BELIEVED KILLED IN ACTION, NOW PRESUMED KILLED IN ACTION.—Sgt. F. J. Day; Sgt. R. E. Drake.

PREVIOUSLY REPORTED MISSING, NOW PRESUMED KILLED IN ACTION.—P/O. L. S. Christman; Sgt. J. E Drew

WOUNDED OR INJURED IN ACTION.—P/O. E. Mendizabal.

MISSING, BELIEVED KILLED IN ACTION.—Sgt. G. P. M. Hardesty.

MISSING.—Sgt. R. J. Jackson; Sgt. H. J. Kelley; Sgt. J. H. Leetham; Sgt. G. J. Masse; Sgt. S. A. Morrison; P/O. A. G. Smith.

KILLED ON ACTIVE SERVICE.—Sgt. E. C. McManaman; Sgt. R. H. Vearncombe.

WOUNDED OR INJURED ON ACTIVE SERVICE.—Sgt. R. W. Dawe; Sgt. A. J. Edwards; P/O. T. C. Robinson; P/O. J. H. Robson.

DIED ON ACTIVE SERVICE.—Sgt. R. A. Bishop; Sgt. D. Houston.

Royal New Zealand Air Force

KILLED IN ACTION.—P/O. R. S. Shield.

PREVIOUSLY REPORTED MISSING, BELIEVED KILLED IN ACTION, NOW PRESUMED KILLED IN ACTION.—P/O. D. McL. Campbell.

PREVIOUSLY REPORTED MISSING, NOW PRESUMED KILLED IN ACTION.—Sgt. M. Evans, D.F.M.; Sgt. D W. Gough; Sgt. A. R. Harris; Sgt. T. G. Webb.

WOUNDED OR INJURED IN ACTION.—Sgt. T. W. Honan.

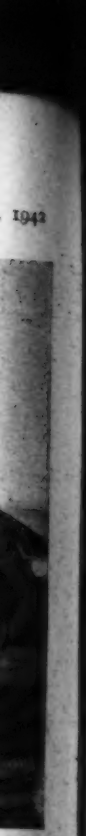
MISSING, BELIEVED KILLED IN ACTION.—Sgt. D. W. Thane.

MISSING, BELIEVED KILLED ON ACTIVE SERVICE.—P/O. J. W. Thomson, D.F.C.

KILLED ON ACTIVE SERVICE.—A/C.1 I. V. A. Anderson.

PREVIOUSLY REPORTED MISSING, BELIEVED KILLED ON ACTIVE SERVICE, NOW PRESUMED KILLED ON ACTIVE SERVICE.—Sgt. R. B. Taylor.

WOUNDED OR INJURED ON ACTIVE SERVICE.—A/C.1 R. S. St. George; Sgt. A. J. Sykes.

South African Air Force

PREVIOUSLY REPORTED MISSING, NOW REPORTED PRISONER OF WAR.—Lt. A. H. M. Moolman